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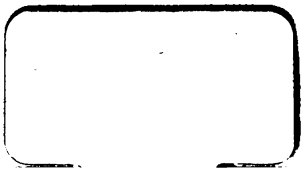
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DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY.

GEOLOGICAL SURVEY OF TEXAS.

JNO. E. HOLLINGSWORTH, Commissioner. E. T. DUMBLE, State Geologist.

SECOND

REPORT OF PROGRESS.

E. T. DUMBLE,
STATE GEOLOGIST.

1891.

AUSTIN:
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1892.

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OFFICE OF COMMISSIONER OF INSURANCE, STATISTICS AND HISTORY,
AUSTIN, TEXAS, February 24, 1892.

Hon. James S. Hogg, Governor, Austin, Texas:

DEAR SIR—I have the honor to transmit herewith a brief statement from Prof. Dumble, State Geologist, showing the principal results of the work in Texas of the Geological Survey for the year 1891.

Your attention is kindly directed to the remarks made by Prof. Dumble under the head of "Water Supply," and especially to the suggestions made with a view of securing a constant supply of water for the Trans-Pecos country.

It is gratifying to note the kind aid tendered by the United States Geological Survey through Major Powell, the Director, in the development of that valuable section of our State.

It affords me pleasure to state just here that the United States Geological Survey has manifested a desire at all times to co-operate with the Texas Survey to the fullest extent, which I assure you is not underestimated by this Survey and is highly appreciated by this Department.

Very truly yours,

(Signed) JOHN E. HOLLINGSWORTH,
Commissioner.

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DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY.

GEOLOGICAL SURVEY OF TEXAS,

AUSTIN, TEXAS, February 20, 1892.

Hon. Jno. E. Hollingsworth, Commissioner of Agriculture, Insurance, Statistics, and History:

DEAR SIR—I have the honor to transmit herewith a report of progress of the work of the Geological Survey of Texas for the year ending December 31st, 1891.

I desire also to express my thanks for the ready assistance you have at all times afforded me during the progress of the work.

Yours very truly,

E. T. DUMBLE,

State Geologist.

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ERRATA.

For "Pliocene," page 12, line 11 from bottom read "Pleistocene."
After "Blue," page 14, line 2 from top, insert "Marls."
For "La Grange," page 15, line 18 from top, read "Lafayette."
For "LaGrange," page 15, line 23 from top, read "Lafayette."
Same line omit "have."
For "La Grange," page 15, line 8 from bottom, read "Lafayette."

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GEOLOGICAL SURVEY OF TEXAS.

SECOND REPORT OF PROGRESS.

JANUARY, 1892.

E. T. DUMBLE, State Geologist.

INTRODUCTION.

In accordance with the original plans of the Survey, while keeping steadily in view the economic features, the first year of each biennial term is devoted mainly to stratigraphical geology. Therefore the report of the work which has been done in the year just closing will deal largely with the details and descriptions of the different formations over which we have worked, although many very important facts regarding the resources of the regions will also be presented for the first time.

The length of time, however, which must necessarily elapse before the detailed reports of the results of the work of the present year can be prepared and published, and the fact that some of these results are of importance, not only in a scientific point of view, but more especially as affecting the interests of the people of the State, render it necessary to issue this Second Report of Progress. In it are included only such facts as have been definitely determined by the field work since the Second Annual Report was issued. Many, which are seemingly of equal interest, await further study and the determinations of the laboratory and of the paleontologist before positive statements can be made regarding them.

WORK OF THE YEAR.

The first four months of the year were spent in the office, working up the results of the field work of the preceding year. In May and June the parties took the field, under instructions which have been faithfully and efficiently carried out, and which have resulted in securing information of greatest value to the State. The work, as outlined in the instructions given, was intended to furnish material for a

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more specific subdivision of the various formations into terranes, and the correlation of the deposits as they occurred in different portions of the State, as well as the further determination of the economic possibilities of each terrane as a basis for the work of next year. One general problem was given each party—the study of the water supply, both surface and artesian.

The map accompanying this report gives the general route of each field party.

The report of Dr. Penrose on the Tertiary deposits of the Gulf Coast gave us the broader characteristics of that formation with admirable clearness, and with such exactness that no great change has been found necessary. It was, however, considered desirable to subdivide the Timber Belt and Fayette beds into such terranes as might be recognizable at this time in order that the horizons of the various clays, lignites, greensand marls, iron ores, etc., might be definitely determined, and time saved in the detailed study of the resources of the formation. This subdivision was also important to enable us to ascertain more positively the conditions of the artesian water supply. In order that there might be no confusion of ideas regarding these horizons, Messrs. Taff, Kennedy and Walker first made an examination of the Cretaceous-Tertiary contact in company, and a brief inspection of the Basal clays as well. Messrs. Walker and Kennedy then made a trip from Terrell to Tyler, across the Basal clays to the Timber Belt beds, and then each of the three took up his separate line of section These sections were made, using the levels of various lines of railroad as a base for obtaining elevations, supplemented by transit lines and lines of levels when necessary. In this way only could we secure sufficiently accurate sections without topographic maps.

Mr. Kennedy was given the eastern and by far the longest line of section. It began at Terrell, in Kaufman county, and followed the line of the Texas & Pacific Railway via Wills Point to Mineola, the International & Great Northern Railroad via Tyler, Jacksonville, Trinity and Corrigan to Colmesniel, and the Sabine & East Texas Railroad to the gulf at Sabine Pass.

Mr. Walker's section was west of the Colorado River, taking the line of the Gulf, Colorado & Santa Fe Railroad from Cameron to Galveston as a base.

Mr. Taff began at Corpus Christi and followed the line of the Texas

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Mexican Railroad to Laredo, the International & Great Northern Railway to Cotulla; thence west to Carrizo Springs and up the Nueces and Leona rivers to Uvalde, where he reached the Cretaceous again.

This gives three complete sections across the Tertiary and Quaternary deposits of the Gulf Coast in addition to those already made by Dr. Penrose and myself, and will enable us to differentiate the formations much more closely than has heretofore been possible.

In addition to the work of these sections, Mr. Kennedy made a detailed study of Houston County, and Mr. Walker a similar study of Washington County and various separated localities of interest.

To secure definite information regarding the country west of the 100th meridian, two sections were made, both starting from the vicinity of San Angelo. Dr. Comstock and party made a close instrumental section southward, through Schleicher, Sutton, Val Verde, Kinney and Maverick counties, to the Rio Grande; thence northward, through Uvalde, Edwards, Bandera, Kerr and Gillespie, connecting again with his work of last year.

Prof. Cummins followed the Cretaceous escarpment west from San Angelo until he reached the Staked Plains. After some local studies, he took his party northward along the foot of the plains to the line of the Fort Worth & Denver Railroad. Turning westward he crossed over into New Mexico, and after examinations of the geology of certain sections, turned south and followed the valley of the Pecos River to Pecos City, having thus completely circled the Staked Plains.

The object of these sections, as stated in my letters of instruction, were:

A more accurate knowledge of the condition of the northern scarp of the Cretaceous table land and its relations to the underlying formations; stratigraphy of the Cretaceous, and manner of disappearance northward under the Plains formation; geology, agriculture, grazing, forest and water conditions of the Staked Plains; character of the Cretaceous table land with its general geology, agricultural, grazing and water conditions; the extension of the Silurian gianticlinal southwest, and its relation to the Cretaceous north and south of its principal manifestation; the stratigraphy of the western Cretaceous, and the determination of the probable thickening of that formation toward the south and west; the character and effect of the basaltic eruptions, the presence or absence of beds of the Upper Cretaceous superimposed on those of

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the Lower in the table land; mineral resources and artesian water conditions of the region.

These two sections, as made by Prof. Cummins and Dr. Comstock, give a connected section from the Canadian River to the Rio Grande, and the results give us a volume of information concerning the general geology, and in regard to the water supply and other conditions of this hitherto little known region.

From Uvalde Mr. Taff took up the study of the Cretaceous, tracing the partings of the limestone and Ponderosa marl from that point to Austin. Having completed this work, I gave him the study of a strip of Cretaceous beginning at the Cretaceous-Carboniferous contact in Lampasas county, crossing the formation to the Cretaceous-Tertiary contact in Williamson county. This had for its object a clearer definition of our Cretaceous in a typical section. and especially the relations of the stratigraphic and economic conditions of the formation. The results are such as will make the further study of the Cretaceous and its resources much simpler than it has been.

Prof. Streeruwitz returned to his work in Trans-Pecos Texas. The United States Geological Survey having kindly consented to aid us by doing the topographic work in that district, and their parties being in the field which we had expected to have to occupy, Prof. Streeruwitz took up the detailed study of a section further east, in the Diabolo and Carrizo Mountains, and when that was completed transferred his camp again to the Quitmans. His results are the accumulation of new facts proving still more strongly the value of our Trans-Pecos country as a source of the precious metals, and of iron, copper, lead and zinc.

The city of Galveston having decided on boring an artesian well three thousand feet in depth, I sent Mr. J. A. Singley to watch its progress, with instructions to use such time as he could, when work was suspended at the well, in making collections of the shells, birds and eggs of the vicinity, and a study of the oyster fishing. The well has now reached a depth of twenty-five hundred feet, and his collections from it will materially aid us to the determination of the thickness of the Quaternary, Miocene and Eocene formations of the State. In addition to the work assigned him, he has collected data of artesian wells in the coast country, which, together with the various sections made, will give us a clearer insight into the artesian water possibilities of the region.

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The Asphaltum deposits of Uvalde having been largely advertised, Mr. Ellsworth made an examination of them, and of those of Burnet as well, the results of which are awaiting the determinations in the laboratory before being published.

My own work during the winter and spring months, aside from the routine duties of the office, was given to the preparation, editing and general oversight of the Second Annual Report, which occupied my time until the latter part of June. I then joined Mr. Taff, and worked the Tertiary section with him from Cotulla to Uvalde. Joining Dr. Comstock's party at Spofford Junction, I accompanied them to Eagle Pass. Leaving them there, I made a section of the Cretaceous formation between Eagle Pass and Del Rio, in the greater part of which I had the assistance of Mr. Owen. After spending a week with Prof. Streeruwitz in the Diabolo Mountains, I returned to Austin, where I received your instructions to take up the Lignite investigation. On the 15th of August, I went to Washington to attend the meeting of the scientific associations, and then sailed for Europe in pursuance of my work on Lignite. The results of this investigation are most satisfactory, and have been briefly submitted to you in my preliminary report. The further determination of the adaptability of the Lignites for the manufacture of gas, gas-oils, parraffine and other similar products, and their possible coking qualities, are now under investigation both in Germany and in our own laboratory.

PERSONNEL.

Mr. Otto Lerch completed the term for which he was engaged, and took service elsewhere.

Mr. J. H. Herndon was relieved from duty as chemist of the Survey on May 6th, 1891. Since that time the work of the laboratory has been carried on by Mr. Magnenat. On the 20th of November I appointed Mr. G. H. Wooten assistant chemist.

Dr. T. B. Comstock resigned his position as Geologist on the Survey to accept the Directorship of the Arizona School of Mines at Tucson, Arizona.

During my absence in the field and on my European trip the office was in charge of Mr. A. C. Gray.

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RESULTS.

General Geology.

TRANS-PECOS TEXAS.

In this district the rocks of Carboniferous age, which had been previously described, have been traced and mapped over a larger area; the age and relations of certain conglomerates, which have been a disturbing element in the study of the region, have been decided; the exact stratigraphic relationship between the schists and the red grit has been determined, through sections fortunately laid open by the torrential rain storm which occurred in the latter part of the summer. Some fossils have been secured, which, although badly preserved, will, it is hoped, give an idea as to their geologic age. The extent of the crystalline schists, which near Eagle Flat are associated with strongly metamorphosed cherty limestones, true marbles, etc , is found to be much greater than was suspected. This is the series of rocks which I suggested in the First Annual Report were probably the equivalents of the Texan system of the Central Mineral District.

THE CANADIAN RIVER—RIO GRANDE SECTION.

The complete results of this section can only be approximated roughly before further study is had of the materials collected It comprises the work of Prof. Cummins, Dr. Comstock, Mr. Taff and myself, and embraces formations from the Carboniferous to the Quaternary. To summarize it briefly:

The boundary of the Staked Plains is described, and its topographic features clearly stated. The strata covering the surface are all found to be of later Tertiary age, certainly not earlier than the Loup Fork Beds, and probably Pliocene in part. These beds thicken toward the northwest, and at the northern scarp of the plains rest directly upon rocks of Triassic age. The Triassic rocks underlie the Plains material as far south as the thirty-third degree of latitude, or a little lower, beyond which point a thin series of the Cretaceous rocks appears between the Triassic and Blanco Canyon beds and thickens towards the south.

On the western side of the Plains the erosion of the Pecos river has cut through the Plains material and underlying formations to its present channel. The determination of the Cretaceous age of the Tucumcari beds, and that these beds are higher in that system than the

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Caprina limestone, and occur without any recognizable beds of the Fredericksburg, or older Cretaceous below them, is of considerable scientific value. The same fact was observed along the entire western side of the plains. The age of the deposits as here given are fully proven by the fossils obtained from them.

South of the Staked Plains lies an elevated Cretaceous table land, rising from the surrounding country both on the north and south by a steep escarpment. The rocks of this plateau are of Lower Cretaceous age, and passing from east to west its lower beds are in contact successively with those of Cambrian, Silurian, Carboniferous, Permian and Triassic age. Passing south to the Rio Grande, successively higher Cretaceous beds are encountered, thickening rapidly and overlapping like shingles upon a roof. The same relations are apparent in higher beds down the Rio Grande from Del Rio to Eagle Pass. The presence of a Pre-Cretaceous fold, which has had a marked influence upon the deposits of that age and upon the subsequent topography and drainage of the State, is determined, as well as the fact that the later basaltic outflows have frequently used the lines of weakness in the trend of the disturbance which formed the fold.

The topographic features of the plateau have been studied, and the difference due to different geologic structure in the river system of the plateau and those lying north of the fold clearly shown.

Much information regarding the basaltic outflow was obtained, but is not yet thoroughly worked out. The present indications are, that they began towards the west, during the Lower Cretaceous period, and continued in operation until the middle of the Upper Cretaceous, possibly extending gradually eastward or northeastward during the time.

Between Del Rio and Eagle Pass—or more properly speaking, Webb Bluff—some forty miles below that city, we have a section of the Upper Cretaceous series which is somewhat different in character from that of the Central Texas area. The Fish beds of the latter are here represented by the Val Verde Flags, a series of limy flags and clays having a thickness of some six hundred feet. The overlying Pinto limestones, which compare in every way with the Austin limestone, are also much more strongly developed, and give a section of some fifteen hundred feet. But the greatest difference is to be observed in the beds which overlie these. Their development is so great that I have placed them in a separate division, and called it the Eagle Pass Division. The two

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lower members of the division, the Upson clays and San Miguel sands, are represented in the Central Texas section by the Blue or Ponderosa and the Navarro or Glauconitic beds, respectively, as fully determined by the fossils found in them; but so far nothing corresponding to the Coal series and Escondido beds (Marine Cretaceous), which overlie these on the Rio Grande, have been recognized in the Colorado section. The total thickness of the different beds is over five thousand feet, if the average dip of one hundred feet per mile, which has been proved above Eagle Pass, holds good for the portion of the section below that point. Proceeding southeast toward the Gulf we find these beds directly overlaid by deposits of Eocene and later age.

CENTRAL CRETACEOUS SECTION.

The results of Mr. Taff's work over the Cretaceous of Central Texas is also of interest. Among these are: The determination of the tripartite character of the Trinity beds, which are shown to consist of the Trinity Sands, Glen Rose beds and Paluxy Sands; the extension of the Paluxy Sands much further south than heretofore observed; the relegation of the Denison beds to their proper position below the Arietina, in place of being the equivalent of the Vola limestone; the modification of the blue (Ponderosa) marl by later Tertiary or Quaternary submergence.

TERTIARY SECTIONS.

The Basal Clays have been extended by this season's work to cover Tertiary materials lying below the beds first described, thus adding considerably to their thickness. The Timber Belt beds, which are of Claiborne age, as determined by their fossil contents, have been more fully studied, but as yet no divisions are made in them, and it will require detailed study over a wider area before this can be done satisfactorily. This is rendered necessary by the character of the materials, which are largely uncompacted, and the manner of their deposition, which was often in bays or coastal lagoons, as well as by the fact that the present comparatively level surface of the area occupied by them affords few opportunities for sections of any considerable length. It may be found practicable, on further investigation, not only to make such divisions as alternating lignite and iron deposits, but also to combine the upper members of the Timber Belt beds and lower part of the Fayette beds into a division representative of the Oligocene.

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The character of the Miocene, to which the Fayette beds have been referred, has been studied and many new facts obtained, including several localities of fossil beds containing casts of a bivalve which Dr. W. H. Dall considers to be possibly a *Macoma.* The specimens occurring at the base of the sandstone are, however, very imperfect.

Overlying these Fayette beds, and stretching still farther to the north and west, are the deposits of gravel and sand. In places these are mixed with clay, especially in the eastern half of the State, but to the west a calcareous material takes the place of the clay and forms a conglomerate, which caps even the higher Cretaceous Hills as far west as Del Rio, and is found in all the canyons making up into the plateau country. In places this calcareous deposit takes the form of beds of limestone, one of which was described by Dr. Penrose under the name Reynosa Beds. I have therefore extended the name to cover the entire division, and as it is probable that it is in these beds that the Equus fauna, described by Prof. Cope from Duval county, was found, they will on that account have to be placed in the Pliocene. This may also include the Texas representatives of the Orange sands, or LaGrange formation as it is now known, which have been up to this time classed as Quaternary by us.

POST TERTIARY DEPOSITS.

The beds which we have classed as Quaternary are the materials corresponding to the LaGrange formation in Eastern Texas and have the overlying coast clays.

Above these come the deposits of the present rivers and gulf coast. The section of the artesian well at Galveston, which is now over 2400 feet in depth, gives an idea of the thickness of the deposits, and of some of the Tertiary as well:

		Total.
Recent	46	
Coastal Clays	269	315
LaGrange formation	143	458
Miocene: Fayette Sands	830	1288
Miocene: Fayette Clays	587	1875
Eocene	550	2425

The fossils found at 2300 feet are those of Burleson shell bluff, which is practically in the direct line of dip from Galveston, distant 140 miles, with a difference in elevation not exceeding 350 feet, which would give these beds the average dip of 18 feet per mile.

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Ecomomic Geology.

TRANS-PECOS TEXAS.

Minerals.—The ore-bearing character of the Carrizo Mountains is fully proved—magnetic iron, copper and lead ores, with silver and gold, having been found, and good results shown wherever prospecting has been done. The Hazel mine was carefully studied, as being the best developed property in the district, and the Third Annual Report will contain a description showing the amount and character of work which has been done in it. The production has already exceeded $60,000, although very little stoping has been done. The fine marbles of this range will some day attract the attention they so richly deserve.

Water Supply.—The first requisite to the proper development of Trans-Pecos Texas is an adequate and constant water supply. Prof. Streeruwitz, in every report he has made, from the beginning of the Survey, has urged this matter strenuously, showing that wells or streams could not be depended on, and that the storage of water in reservoirs was the only practical way of accomplishing this end. He also shows that the character of the topography and the rock formation is such that there are many places at which storage reservoirs could be built at moderate cost, which would be suitably located for irrigating large bodies of very fertile lands, or for use in mining operations, or for the raising of stock His own observations, as well as those of the government observers at Fort Davis and Fort Bliss, prove that the annual rainfall is sufficient to give an adequate supply for all these purposes if it is properly cared for. The greatest obstacle to be overcome is the fact of the larger part of the lands being sectionized, and the alternating sections belonging to the State and railroads respectively, so that no one could get a sufficient amount of land in a body to warrant the expenditure necessary for building a dam

During my visit to his camp in the Diabolo Mountains, last summer, this matter was one of the most constant discussion, and it finally occurred to me that there might be a possibility of the inauguration of this work by the State, provided locations could be found which would be entirely on State lands, and that it would be possible to utilize convict labor in building the dams and in the necessary preparations for irrigation. The State, in its various branches of University, Public School, Asylum and unoccupied lands, is most largely interested in this section. These lands are practically valueless in their present

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waterless condition, whereas, with such a supply of water as can be secured by this means they can be made to "blossom as the rose" and made to support a large population and remunerate the State a thousand fold for the outlay necessary for their reclamation.

Upon my return to Austin the matter was referred to yourself and Governor Hogg, and instructions were given us to ascertain whether suitable localities could be found affecting only State lands.

Some difficulty was experienced in locating such corners as would show that the land was all undoubtedly public land, but there are places, without doubt, in the region northeast of Van Horn, which will afford suitable localities for such reservoirs. Major Powell, Director of the United States Geological Survey, has promised not only to designate such localities as may be found by the topographic parties at work in the district, but also to estimate cubical contents, height of dam and other details, thereby greatly facilitating our work.

CANADIAN—RIO GRANDE SECTION.

As has been stated, this section embraces the territory between the 100th meridian and the Pecos, from the Canadian river to the Rio Grande.

The water supply of the Plains was fully investigated, and it was found that although there is no hope of obtaining artesian water, except in rare instances, the supply to be had in wells is practically unlimited. These wells vary in depth from twenty feet to three hundred feet, according to localities. The springs and streams find their supply from the same source as that of the wells. West of the Plains water is easily obtained in shallow wells, while along the Pecos, the eastern side of the Gaudalupe Mountains, the supply is abundant, and in places artesian flows can be secured. The only minerals of the Plains are the gypsum and salt. The soils are of great fertility, and the rainfall, although not so abundant as it is farther east, is nevertheless fully sufficient to mature good crops in most seasons, for the reason that it falls during the time at which it can be of most service—in the summer.

Perhaps one of the most useful results of the season's work is the demonstration of the agricultural capacity of the Plateau region in which the valley soils, which cover a large area in the aggregate, are not only excellently adapted for tillage, but are so situated that they can be irrigated in many places from the abundant supply of water

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that was found to exist at no great depth below the surface, "which appears to be a vast body of underground water lying like an overflowing lake beneath this great divide." The great value of the determination of this immense water supply, underlying the Staked Plains and the Plateau, which is accessible by wells over so wide an area and breaks out in bold and never-failing springs in so many places, is so self evident that words could not enhance it.

The more barren highlands are well adapted for sheep raising, while the pecan growth of the southward flowing river valleys is of such extent and character as to furnish the basis for a great industry in itself.

The mineral resources of the Plateau are confined to ochres, kaolin, lime and cement materials and building stones.

The principal economic materials of the Cretaceous region south of the Plateau are the coal, asphaltum, clays and artesian water. The Eagle Pass coal basin has been described previously. The northern outcrop of the coal seam has now been traced and mapped, and its relations to the underlying and overlying materials studied in such a manner that they can be used as indicators of its presence and its approximate depth at any given point, or its entire absence.

The asphaltum deposits, which were first described by Mr. Owen in the First Report of Progress, have been examined, and my first statements regarding their character and value verified and enlarged. They are much more extensive than has previously been suspected.

CENTRAL CRETACEOUS SECTION.

East of longitude 98° 30′, and embracing the black waxy prairies.

The horizon of the celestite deposits was determined, and the building stones, sand, brick-clay, lime and cement material, road material, soils and marls and artesian water conditions and irrigation facilities were carefully studied with very satisfactory results. Indeed it is safe to assert that with the work now done the classification and description of the principal soils of the Cretaceous area north of the Colorado river, and even of a large portion of that south, can be taken up and completed. A large number of soil analyses are now under way, which will give the true character of the soils of the various horizons and afford the knowledge necessary for suggesting proper means for their amelioration when necessary. It is probable also that all needed

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materials for this purpose will be found in the immediate vicinity of the localities at which it is required, or at least within the limits of the formation.

TERTIARY SECTIONS.

From the black waxy prairies to the Gulf.

In this area the wide spread character of the lignite beds has been clearly demonstrated, new and valuable deposits of iron ores located, the position of many valuable beds of clays, diatomaceous earth, greensand marls and building stones determined, and the salt deposits have been more clearly defined and described.

The artesian water conditions are found to be favorable over a large district, but the widespread character of the gravel and accompanying sands of the southwestern portion of the State prevented our getting the necessary information in that region to enable us to speak positively as to the likelihood of flowing wells, as we had hoped to do.

The character of the soil of this area, with a few exceptions in East Texas, has not been properly appreciated. Many of them are of excellent quality, and by proper drainage and cultivation will yield large returns to agriculture. They are now being studied in the laboratory, preparatory to a classification according to their origin and present qualities. The greensands have had special attention. Where they have been tried by farmers they have fully borne out all the claims which have been made for them by the Survey. Thus practical agriculture again proves the value of chemical analysis as a basis for restoring the fertility of the soil.

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REPORT OF MR. W. H. VON STREERUWITZ.

INTRODUCTION.

AUSTIN, TEXAS, January, 1892.

Mr. E. T. Dumble, State Geologist:

DEAR SIR—In obedience to your instructions, I took the field in West Texas, May 15, 1891, to proceed with the topography of Trans-Pecos Texas, and to study the geological and particularly the economical features of this part of the State.

I organized my party with Mr. Ralph Wyschetzki and Konrad Girsewald as assistants, securing the other necessary help in the only way possible to engage it in the West—the first best men willing to take employment. To engage cook or drivers in the east would not only be too expensive on account of traveling expenses, but inexperienced Eastern men, with few exceptions, are not of much use in the unsettled extreme west, where familiarity with camp life, knowledge of the country, and aptitude and willingness to undergo hardships of any kind are the principal conditions of usefulness.

Having met Mr. Goode, of the United States Geological Survey, with two topographical parties in the field to work up the country between the 31st and 32d degrees of latitude, and 105th and 106th degrees of longitude, I took advantage of this, stopped the topographical parties inside of these boundaries, and commenced to work up the mineral district of the Carrizo Mountains and southern part of the Sierra Diabolo, with the Hazel mine and numerous outcrops and indications and a few prospects on silver-bearing copper ores. I mapped part of the country, and took a number of sections which will materially assist in the determination of the very extensive field of the crystalline schists and their relation to the plutonic and volcanic eruptive rocks, as well as of the superimposed sedimentary strata.

I could not effect an extension of the sections to the Guadalupe range, and thus eventually connect them with the mountains north of the 32d degree of latitude, since my wagons and animals, which had been in service under very trying circumstances since the beginning of the Survey, had become worn out to such an extent that I dared only risk short trips, and could not go far from the railroad on account of the scarcity of water.

I therefore reconnoitered the Wiley Mountains, and later the northern portion of the Van Horn Mountains. After placing the animals (three horses and two mules) with the wrecks of the water and baggage wagon and a well-worn ambulance (the relic left by Mr. Tarr in Tojah) with the camp outfit at Phinney's ranch, disbanded the party and started on with Mr. Wyschetzki and Girsewald for Austin, on the fourth of October.

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I regard it my pleasant duty to express to these two gentlemen my sincere thanks for their unremitting zeal in topographical and other work, and for their ever cheerful endurance of hardships under the most trying circumstances.

I have the honor to submit with this a short preliminary report referring to those parts of my districts to which the work was mostly confined, referring particularly to the Hazel mine to prove that, besides the numerous outcrops, indications and prospects mentioned in former reports, actual mining is carried on in West Texas, not only in the more generally known Shafter mine in the Chinatti Mountains (Sierra Pitares), in Presidio county, but also in El Paso county, and thus to demonstrate repeatedly that Trans-Pecos Texas, far from being a valueless desert, deserves the fullest attention of the Legislature and of the administration of our State.

GEOLOGY.

The mountains between the longitudes 105 degrees and 104 degrees 55 minutes west of Greenwich, lying between parallel 30:55 and the continuous high limestone cliffs about eight miles north of the Texas & Pacific Railroad, are generally called the Sierra Carrizo, and the mountain range extending north from the cliffs towards and partly alongside of the Salt Lake Valley and terminating at the Sierra Prieta are known as the Sierra Diabolo. This is here accepted as a correct definition of the two ranges.

The principal portion of the southern part of the Carrizo Mountains is built up of Crystalline Schists, such as talcose, micaceous, argillaceous and greenstone schists, with numerous quartz veins and occasional basaltic intrusions. These schists, which dip at angles varying from twenty-three to eighty-five degrees, are flanked on their eastern and southern slopes by limestones, which also appear, but less distinctly, in the west. These limestones are only slightly tilted, and rest not quite conformably, on a sparsely exposed, dark red or brownish gritty sandstone, in which no fossils have yet been found. Further east, toward Van Horn station, these grits extend in lower hills, denuded of the limestone. Some of these hills are considerably tilted, but evidently from having been underwashed and having slipped down.

The tilted condition of the schists is evidently due to the upheaval of granitic rock which in the passes between Allamore and Van Horn, and again on the western slope of this mountain group, eruptives appear in small patches below and between the schist rocks.

The limestones of the cliffs north of the Texas & Pacific Railroad rest in most places visibly but slightly unconformably, on red and brownish grits, alternating finer and coarser, and interstratified with layers of conglomerate cemented by a red gritty mass. The thickness

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of this gritty and conglomerate horizon varies where exposed from six feet to more than two hundred feet, and it is probably thicker in places where its base cannot be ascertained; on the other hand, the limestone cliffs near Eagle Flat rest seemingly directly on the schistose layers without intervening grit deposits

An extraordinarily heavy rain made an exposure at the limestone cliff along the Texas & Pacific railroad about seven miles west from Van Horn station, which brought to view the contact between the schists and the overlying grit. This rests nearly horizontally on ten to twelve inches of a transition breccia superimposed on the crystalline schists, which here dip nearly perpendicularly (eighty-three degrees).

The brecciatic conglomerates which are seemingly interposed between the limestone layers, which appear on the north side of this range of cliffs and locally in other places, are evidently only the indurated talus of the cliff material. They consist of fragments of superimposed strata cemented by a calcareous matrix. Their age is probably Cretaceous. I traced the grits about sixteen miles north on the eastern side of the Diabolo Mountains, and their presence is evident along the Texas & Pacific Railroad from Allamore, where I also observed their contact with the crystalline schists. They also appear south of Rattlesnake tank, on the west side of the Van Horn Mountains.

The greater part of the area between the front cliffs (on the Texas & Pacific Railroad) and the southern cliff of the Sierra Diabolo proper, is occupied by gentle hills composed of a red, fine grained sandstone without distinctly visible stratification, which contains no vegetable or animal fossils, and weathering in small rounded boulders. The grains of sand are cemented by a silico-calcareous mass. The base of this sandstone has not yet been reached at a depth of 575 feet at the Hazel Mine

The mountain range, or rather the mountain groups east of the Sierra Diabolo proper, are flanked by limestones of Carboniferous age, resting on the before mentioned grits, which here are exposed to a thickness of several hundred feet. Up to this time I could find no contact with the schists in these mountain groups or in the Sierra Diabolo proper as far as I carried on the investigation. In the western part of the Carrizo range, north of the Texas & Pacific Railroad, the schists rocks are exposed, associated with strongly metamorphosed cherty limestones, true marbles, quartzitic rocks, older conglomerates and occasionally serpentinous masses. Though up to the present I have found no granitic eruption in the Carrizo Mountains north of the railroad, I do not doubt that the tilting and metamorphism of the limestone as well as the other rocks is due to the action of plutonic eruptions (feldspathic rock), which are plainly visible at Eagle Flat and

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also mentioned above in the Carrizo group south of the Texas & Pacific Railroad. In addition to these I may mention more remote granitic mountain groups and mountain ranges in Trans-Pecos Texas, which, although separated by very extensive flats, and then covered by several thousand feet of sand, clay, gravel—in short, detritus of any kind—leaving hardly any connection by lower granitic ranges covered up by later deposits.

The Wiley Mountains southeast of Van Horn are in fact only a portion of basaltic upheavals connecting the mountains west of Valentine with the Apache group through the Chispa range.

I had not the time to go beyond a hurried reconnoitering, which, however, proved that the limestone flanking the west slope, which on the north side extends towards Kent, on the Texas Pacific railroad, rests also here unconformably directly on the crystalline schists, which, however, in their upper portion are more decomposed than at other places observed changing into micaceous sandy shales.

A basin on the east side of these western flanking cliffs, where it is not covered by recent deposits, displays a granite bottom broken up and surrounded by intrusive, protrusive and extrusive basaltic eruptions, the granite as well as the basaltic rock showing many phases of contact metamorphism. The granite rises to the east of this peak, and by reason of not having been subject to equally strong destructive forces as the western part, shows plainly the action of the protrusive influence of the later volcanic eruptions by the bends and folds in the lower and the rents in the upper portions. Further east the granite slopes down and disappears again under many miles of the flat between the Wiley and the Apache mountains, which, as is usually the case, has obliterated all visible connection between the two mountain groups. The connecting traces between the newer eruptive material along the Rio Grande and the Apache group, we find in the Chispa range near Chispa Station on the Southern Pacific Railroad and in the Van Horn Mountains, where we also meet granite trachitic and crystalline schistose rocks.

ECONOMIC GEOLOGY.

As far as the ore-bearing character of the mountain ranges and groups, mentioned in this preliminary report, is concerned, I regard the Carrizo group south of the Texas Pacific Railroad an outspoken mineral district. The little prospecting which has been done in these mountains has brought very good results. Uncle Jake's diggings showed good silver bearing copper ore last summer, though the shaft was still say fifteen or twenty feet from the main lead, and the prospect near the railroad six miles west from Van Horn, sunk on an outcrop of iron (magnetic and hematite) two to three feet wide, carries some silver close to the surface, and Anglesite (sulphate of lead) crys-

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tals and copperstain appear with the Goethite of this prospect at the depth of about five feet. Some older prospects nearer to Bass Canyon, though only superficial diggings, brought comparatively very good specimens containing, in addition to the lead (galena and carbonate) and copper (malachite and azurite), silver and very strong traces of gold. Tradition tells also of an old Spanish or Mexican mine in the southern portion of these mountains, which tradition, contrary to most others, seems to be based on facts; at least I found in an old correspondence between two frontier explorers this Spanish mine mentioned as the starting point for a certain trip. But this correspondence reports the mine, thirty-five years ago, as nearly obliterated.

But besides the prospects and the traditions, there are numerous quartz veins in these mountain groups, three of which deserve particular mention. They are strongly ferruginous on the surface, of considerable width, varying from a few feet to twenty and more feet, and they can be traced for several miles, running nearly parallel with each other, and crossed by a fourth one underneath, on a slightly acute angle.

In the Carrizo range, north of the Texas Pacific Railroad, the prospects are more numerous, partly because the working at the Hazel mine exerted an encouraging influence, and because the bright copper stain on the surface looked more inviting to inexperienced prospectors. The presence of a little water in this range has probably also some influence.

At the Hazel mine a silico-calcareous gangue, of an average width of thirty-four feet, is worked for strongly argentiferous copper sulphides, the veins of which run frequently with heavy spar. The output of this mine up to June, 1891, was about $66,000, though the work up to this time has only been shafting and drifting preparatory to stoping, and all low-grade ores containing twenty ounces or less of silver. A large pocket of rich ore was struck and worked out through the greater part of the third level, but the ore in sight in the drift justifies the opinion that the Hazel mine is a very promising mining object.

But though there are numerically more prospect holes in this part of the Carrizos, they are, with the exception of the Hazel mine, hardly better explored than those in the part south of the railroad; and even the best developed prospects, such as the Black Shaft, Schleicher's mine, Don Quixote and Sancho Panza, are not sufficiently explored. It is, however, a fact that every one of these, and many other prospects in this mountain range, "show up" just as well as the Hazel mine in its first stages of development.

Besides iron and argentiferous copper ores containing traces of gold —the last, probably, from pyrites in the ores—no other metals were found in the northern range of the Sierra Carrizo, but the marbles will no doubt by and by be appreciated as they deserve, and it is very prob-

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able that more careful prospecting will detect the same variety of valuable minerals as are found in the more western mountains.

The Wiley Mountains are hardly well enough known to permit an expression of opinion about their ore-bearing character. As a rule newer eruptive rocks are considered less favoarble to ore-bearing than the older ones; but here the newer eruptives have broken through older ones, which are regarded as good ore bearers, and though the indications are scarcer and fainter than in the Carrizo Mountains, there are nevertheless some which are worth prospecting, and there is no doubt that a more careful examination will disclose more and perhaps better indications than those found in hasty reconnoitering. The contacts between the granites and schists I think would be the best places for prospecting; which statement, in all probability, will hold good also for the Apache (Davis) Mountains.

I had not the time for sufficient investigation to form an opinion about the ore-bearing character of the Van Horn Mountains. There has been no prospecting up to this time; but reconnoitering the big valley south of Haskell I found, in the ravines of the higher portions of the valley, spar leads and strongly mineralized quartz outcrops, the aspect of which will justify their closer examination in the field and laboratory; still more so as I found in the crystalline schists distinct indications of copper, and since the grits, which are so conspicuous in the mineral district of the Carrizo Mountains north of the Texas Pacific Railroad, appears also in the Van Horn range. I have found no granite exposed to view in the northern part of the Van Horn Mountains, but the schists, no doubt, are like those in the Carrizo Mountains and in the spur in the neighborhood of Mica tanks which are brought up and tilted by granitic upheavals. It is hoped that a closer examination of the ravines will disclose not only distinct proof of the presence of plutonic eruptive rocks, but also of the existence of such ore indications as I have found, I may say invariably, connected with the granitic and porphyritic rocks of West Texas. In conclusion, I have to repeat the assertion I have made in every one of my former reports, viz: that most of the mountain ranges of Trans-Pecos Texas are ore bearing, and that the indications to guide prospectors are as definite as in any mineral district of the United States or Mexico. I also repeat, that a greater part of the flats, basins or parks, or by whatever name we may choose to call the extensive spaces between the mountain ranges, are covered with fertile soil which can be adapted for agricultural and horticultural purposes by irrigation. I also repeat, that irrigation by storage tanks in the mountains is feasible as far as the technical and economical questions are concerned. And though it may become as monotonous as Cato's "*Ego autem censeo Carthaginem esse delendam,*" I repeatedly point to the drawbacks to the development of this valua-

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ble portion of the State, the defective surveys, the title clouds in the shape of Mexican and Spanish grants, the neglect of which (questionable as they may be) has cost the State about five hundred thousand dollars lost in unassessed and consequently uncollected taxes.

I also repeat that the alternate section system makes the portions fit for agriculture absolutely worthless, as well as of State, corporations and private lands, in the mountainous regions of Trans-Pecos Texas, as it never would pay to incur the expense of making arrangements for the irrigation of a single section of land, even if the topographical features of the country would admit it.

(Signed) W. H. VON STREERUWITZ,
Geologist for West Texas.

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REPORT OF MR. W. F. CUMMINS.

INTRODUCTION.

Mr. E. T. Dumble, State Geologist.

In compliance with instructions received from you, on my arrival at Austin, at the close of the past season's field work, I herewith submit a brief resume of the geological reconnoissance made by me in the northwestern part of the State, since the publication of the Second Annual Report of the State Survey.

The territory embraced in this resume includes those portions of the State of Texas and Territory of New Mexico, known as the "Llano Estacado, or Staked Plains."

It is intended only to show such results of my geological observations, as to the general character and economic resources and capacities of the district, as are considered definitely settled at the close of the field work, and it is intended to follow this brief statement with a more amplified and specific report in the future.

In making geological observations one cannot always be restricted by political and arbitrary lines, as it is very often the case that facts needed for the solution of some geological or economical question can only be had by an examination of a district outside of the political boundary within which the question is of importance and interest, and the necessity of going outside the given territory becomes imperative when, as was the case in this instance, the territory beyond has never been examined and reported upon by a competent observer.

The subject to be investigated, which took me beyond the State boundary, was that of the possibility of obtaining artesian water on the Staked Plains. a question of very great importance to that part of Texas.

It is a conceded fact, that if there be a supply of artesian water beneath the high plateau of the Plains, the source of that supply would be in the upturned edges of the underlying strata along the foot of the mountains in New Mexico, and no one would attempt a definite solution of the question without first knowing the geological formation between the western escarpment of the Staked Plains and the foot of the mountain range beyond.

We found a district of country, between the foot of the Plains and the mountain range, three hundred miles long and from seventy-five to one hundred miles wide. This area had been almost entirely unexplored by any geologist. Prof. Jules Marcou traveled hurriedly across the upper or northern end of this district in 1852, and Dr. Shumard and others traveled across the southern end of it in 1855; but aside

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from their published reports the geological features of the country were not known, and therefore I could only get the facts desired by going into the district myself.

BOUNDARY OF THE STAKED PLAINS.

So far as I am informed, no one has heretofore attempted to give the boundaries of what is known as the Staked Plains. The high plateau called by this name has been known to be in the northwestern part of Texas and the eastern part of New Mexico, but just what part of the country is entitled to that appellation is not so well known.

During the past summer I traveled entirely around this high plateau, and I am enabled to give its boundaries with a tolerable degree of accuracy.

The eastern, northern and western limits are marked by high precipitous escarpments, ranging in height from one hundred to four hundred feet. The white, precipitous cliffs can be seen for a long distance as they are approached, and the outstanding peaks look like huge fortifications.

The southern limit is not so well marked, but ends in a gradual slope, following the inclination of the strata.

The eastern boundary of the Staked Plains may properly be said to begin at Big Springs, although there is a wide valley of erosion between the high Cretaceous ridge that extends from the Cretaceous area of Middle Texas, just south of and parallel with the line of the Texas & Pacific Railroad, leaving a broad valley of erosion between that ridge and the Cretaceous area of Southern Texas. South of this ridge there is a continuation of the high escarpment of the eastern border of the Staked Plains, which extends to a point twenty miles south of San Angelo.

The extension of the eastern boundary of the Staked Plains northward from Big Springs passes through Borden county near the center, and thence crossing the Double Mountain fork of the Brazos river about fifteen miles west of the mouth of the Yellow House canyon. Thence to Dockum, and along the western line of Motley county, crossing the Prairie Dog fork of Red River a few miles above the mouth of Mulberry canyon, and crossing the line of the Fort Worth & Denver Railroad at Goodnight Station, and thence to the Canadian river.

The northern boundary is marked by a high escarpment along the south side of the Canadian river, and at a distance of from ten to twenty miles from it. I have traced this escarpment as far westward as the road leading from Tucumcari to Fort Sumner, on the Pecos river.

In traveling southward from Tucumcari Mountain to Fort Sumner,

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the road passes across an arm of the Plains that is about fifteen miles wide, extending in a northwest direction, but just how far it goes in that direction I have not been able to determine.

The western boundary is a high, bold escarpment, running almost parallel with the Pecos river, and at a distance of from thirty to fifty miles away, as far down as the Horsehead crossing, where the high bluffs approach the river.

TOPOGRAPHIC FEATURES.

The high plateau of the Staked Plains is but the remnant of a plain that once extended continuously from the foot of the Guadalupe Mountain range on the west to some undetermined boundary east of the present limits of the Plains. At some time during the later Tertiary or early Quaternary epochs the strata were elevated from the northwest, and the waters of what was then an inland sea were drained off to the eastward, and made the great valley of erosion that now exists between the foot of the Plains on the east and the Cretaceous hills west of the Cretaceous formation of Eastern Texas, and also made our present river channels on the east side of the Plains.

Since the tilting of the strata the Pecos river has cut through the overlying strata, and from the foot of the mountains where it makes its entrance into the plain to Horsehead crossing the Triassic and Permian strata are exposed. In places west of the Pecos river the same formation occurs as that which constitutes the upper strata of the Staked Plains, showing that this formation was once continuous over the whole area now occupied by the broad valley of the Pecos river.

The Staked Plains is one immense level plateau, with only slight undulations, dipping gently to the southeast. The dip, however, is so small that it is almost imperceptible to general observation. The country is so level that travel which way you will you seem to be going uphill.

This plateau is cut into in places by deep canyons, that extend for miles and miles, with precipitous, perpendicular sides, without a single place where they can be descended by a man on horseback. They are from one hundred to four hundred feet in height.

The principal canyons are: Yellow House, Blanco, Mulberry and Palo Duro, with their lateral branches, yet there are many others of less length and notoriety.

West of Duro, a station on the Texas and Pacific Railroad, near the western edge of the Plains, is a range of white quartz sand hills extending northwestward for over sixty miles, and from ten to twenty miles wide. They have a general height of from ten to forty feet, and are covered with "shin oak." These hills have evidently been made by the action of the winds. The source of the sand from which these

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hills are made has not been definitely determined, nor just why they have arranged themselves in a belt extending from north to south at this particular locality.

GEOLOGY OF THE STAKED PLAINS.

Heretofore very little has been known of the geological formation of the Staked Plains. It has been generally supposed to be Cretaceous. The observations of this year disclose the fact that the Cretaceous does not appear as the upper strata of the Staked Plains anywhere north of the line of the Texas and Pacific Railroad, except it be a very narrow strip along the eastern edge where the overlying strata has been eroded.

The strata forming the upper part of the Staked Plains belong to the later Tertiary, and were described by this writer under the name of "Blanco canyon beds" in the First Annual Report of the State Survey, 1889.

This formation thickens towards the northwest. At Big Springs the formation is less than twenty feet thick, while at Amarillo it is three hundred feet thick, and at the extreme northwestern extension of the Plains it has attained a thickness of over four hundred feet. It is the lower portion of the beds that thin out towards the southeast; the upper beds of white, chalky, indurated limestone is continuous, and found at the top everywhere over the entire area, except in such places as are covered by soil. The beds vary somewhat in composition at different localities, but everywhere they have the same general characteristics, and are easily identified.

The Tertiary of the Staked Plains is underlain partly by the Cretaceous and partly by the Triassic.

All that part of the country situated southeastward from a line beginning at a point on the Double Mountain Fork of the Brazos river, about where the eastern line of Garza county crosses the river, and running thence southeast to the Pecos river, is underlain by the Cretaceous, and all that part of the Plains situated northwestward from that line, except a very small area at the head of Fossil creek in New Mexico, southeastward from Tucumcari Mountain, is underlain by the Triassic. At that place mentioned, the Tucumcari beds, which are Cretaceous, extend under the Tertiary and over the Triassic.

The Tucumcari beds are Cretaceous, but belong to a different horizon in the Cretaceous series from that at Big Springs and elsewhere along the eastern escarpment of the Staked Plains.

The reason for believing these beds Cretaceous will be more fully set out in the Annual Report, when I shall have had time to study more closely the collections made at that locality. It is enough to say now that my conclusions are based upon the character of invertebrate fos-

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sils collected in that locality, which taken as a whole clearly indicate to me the Cretaceous age of the strata.

The flora from these beds was not so extensive as the invertebrate fossils, but the evidence it furnished of the Cretaceous age of the strata was none the less decisive. The specimens obtained belonged to the dicotyledons, and that family of plants have never been found in strata older than the Cretaceous.

There is no perceptible unconformity between the upper strata of the Plains and that of the underlying beds, except in the vicinity of the head of Fossil creek in New Mexico, where the Tucumcari beds lie between the Triassic and Tertiary, and there the unconformity is very perceptible, as the Tucumcari beds dip to the southeast at a considerably greater angle than do the beds above, yet this is only local, for the Tucumcari beds at other localities where they were seen were almost horizontal.

GEOLOGICAL FEATURES WEST OF THE STAKED PLAINS.

There is a belt of country situated between the western escarpment of the Staked Plains and the foot of the Gaudalupe Mountain range beyond, that is about three hundred miles long from north to south and from sixty to one hundred miles wide. At one period the strata composing the upper strata of the Staked Plains extended entirely over this district, as is evidenced by the fact that there are remnants of that strata still remaining at various localities throughout the entire area. At a later period occurred a deep erosion which has carried away in places the upper strata and exposed the underlying Cretaceous, Triassic, Permian and Carboniferous formations.

Through this belt of country the Pecos river has cut a deep wide valley diagonally from northwest to southeast. The immediate channel of the river for most of the way is deep and tortuous. The drainage is all from the western side of the river.

The dip of the strata is from the northwest, with an occasional fold in the strata running parallel with the mountain range.

The Triassic beds occur all along the foot of the western escarpment of the Plains and are composed of sandstone and red clay.

The largest part of this belt of country, between the foot of the Plains and the mountains, is covered by the upper beds of the Permian, composed of strata very much the same as that of the upper Permian east of the Staked Plains. The strata of the Permian comprise red clays, red sandstone, white sandstone, limestone, gypsum beds, and a peculiar conglomerate of clay nodules and iron.

The most of the red clays are heavily charged with common salt and gypsum. Interstratified with the clays and sandstones are beds of massive gypsum.

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The strata of the Gaudalupe Mountains from bottom to top belong to the Carboniferous formation. Beds of this age also extend into the valley below. The strata in the mountains dip at various angles, and are more or less metamorphosed. The mountain strata are principally limestone. The strata in the valleys approach nearer to a horizontal position and are composed of sandstones, shales, and limestones with fossils characteristic of that age. Between the mountains and the western escarpment of the gypsum beds of the Permian there is a wide valley, over which there is spread a thick bed of Quaternary drift.

Cretaceous beds were not seen after leaving Tucumcari, until we reached the country south of the southern extension of the Guadalupe Mountains. The highest part of the Cretaceous beds that we saw north of the Davis Mountains was the Arietina beds, or the upper part of the Washita division; below them were the beds bearing *Ostrea quadruplicata* Shumard. And only further eastward were the lower beds seen.

The Tertiary beds, the same as those forming the upper part of the Staked Plains, occur at various localities in this district in broad valleys that reach occasionally from the foot of the mountains to the river on its western side. I saw a few patches of it east of the river. There are also large areas covered with Quaternary drift, composed of the pebbles brought down from the mountain sides. This drift is not confined to the river valleys, but is also spread out over the high plateaus.

There is some evidence that at a late geological period there existed an inland fresh water lake, in that part of the district under consideration, which was afterwards drained by the Pecos river, when it cut through the heavy Cretaceous strata on the south We have collected some facts during the past summer that indicate such a state of things, but they have not been sufficiently studied to warrant a positive assertion on the subject.

WATER SUPPLY.

Water sufficient for all purposes is obtained on the Staked Plains from shallow wells, lakes and the streams, and springs found in the various canyons.

The water-bearing stratum lies at the base of the Tertiary or upper division of the plateau. This water has very little hydrostatic pressure, and as a consequence it rises very little in any of the wells. As has been stated elsewhere in this paper, this strata thickens toward the northwest, and as a consequence the wells increase in depth in that direction. The supply of water in this stratum is practically inexhaustible, and an abundant supply of water may be had at any given locality by sinking wells down to this water-bearing bed. The wells that have already been put down range in depth from twenty to three hundred

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feet, according to the locality where they were dug. Hundreds of wells have been put down on the Plains, and I have never heard of one where water was not found if the depth was sufficient to reach the base of the Tertiary.

In the southern part the water is obtained in shallow wells by going through the upper part of the Cretaceous beds and piercing the bed of sand below, which is known as the Trinity sands. In that part of the Plains when the Tertiary is of suitable thickness there are therefore two water-bearing beds.

LAKES.—At many places on the Staked Plains there are shallow lakes, ranging in depth from two to eight feet, that afford water for several months in the year, and some of them have water in them the year round They are supplied with water by surface drainage, and there being no outlet it stands there until exhausted by evaporation. The evaporation is so great, and the rainfall so uncertain, that they cannot be relied on as a constant source of supply for water. These lakes vary in size from a few acres to several hundred in area. The water is generally fresh, but some are highly impregnated with common salt. These latter will be mentioned in another place in this paper.

SPRINGS.—Along the eastern and northern escarpment of the Plains there are a great number of springs, that receive their supply of water from the same stratum as do the shallow wells already mentioned. At Big Spring, and the other springs in that vicinity, the water comes from the Trinity sands, while those farther northward get their water from the Tertiary or Triassic. Along the several canyons, from head to mouth, there are springs of various sizes, all of which get their water from the same source.

STREAMS.—In all the principal canyons there are streams that furnish a constant supply of water in various amounts. It is very often the case that the sand is so deep in the channels of these creeks and rivers that the water does not appear at the surface except during a freshet, or in places where the sand has been washed away, but it is always possible to get an abundant supply of water by digging into the sand a foot or two. As an example of the amount of water to be had in one of these canyon streams, that of White River, in Blanco canyon, may be cited. When I was at the Falls of the river, there was about 13,000,000 gallons of water passing over the falls per day. There were also several large springs whose waters flowed into the river below, and yet with all this flow, at a point a few miles below there was very little water to be seen in the river bed. The water in these springs and streams is generally free from salts, and it is only after they reach the gypsum beds of the Permian that they become impregnated with the salts that render the water so unpalatable.

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WATER NORTH AND WEST OF THE STAKED PLAINS

At many places along the northern escarpment of the Staked Plains there are small springs which come from the lower beds of the Plains, and at some places there are heavy sand beds in which an abundant supply of good water has been obtained from wells sunk to the depth of from ten to thirty feet. Just north of the point where the west line of Texas ascends the Plains there is a range of sand hills running parallel with the north escarpment of the Plains and at a distance of five or six miles, for a distance of nearly fifty miles, and in these hills water can be had in very shallow wells.

West of the Pecos river in New Mexico and the upper part of Texas there are a great number of very fine springs, some of them ranking in the quantity of water they furnish with the largest springs in the world. A more particular description of them will be given later.

With one or two exceptions these springs are all on the west side of the river, and those that form the exception are in the immediate vicinity of the river channel.

The principal sources of the water in these springs is in the mountain range to the westward. There the water falls in copious showers, and running down into the valleys is absorbed by the heavy beds of drift, and is finally conducted into the lower beds of the Tertiary, thus forming the same water beds in geologic age that is found at the bottom of the Tertiary strata on the Staked Plains. The Pecos river having cut this water-bearing bed in two, as soon as the water reaches this valley of erosion, it rushes out in the big springs mentioned.

Between the anticlinal axis which runs out from the mountains toward the plains below, these beds of Tertiary strata remain, and wherever these immense troughs exist there is an abundance of good, clear, sweet water, and these troughs furnish the storage reservoirs for the springs, that are unaffected by either drouth or floods.

Water is found also in the Permian and Carboniferous strata as well as in the Quaternary drift.

Some of the water coming from the Carboniferous is so impregnated with salts as to be unpalatable, and all the water in the Permian is so largely saturated with salts of various kinds that it is hardly palatable for either man or beast. It is said that the stock become used to that kind of water and do as well as when using the purest.

The water from the Quaternary is generally pure and good.

At the head of Delaware Creek are two springs within a few feet of each other—one of them comes from the Quaternary and the other from a fracture in the Carboniferous sandstone. That which comes from the Quaternary is sweet and good, while that from the Carboniferous is highly impregnated with salts, and emits a strong smell of sulphureted hydrogen.

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WELLS.—Shallow wells are numerous along the western side of the river between Roswell and Eddy in New Mexico The stage company found no difficulty in getting water for their stands at any point along that route. These wells are from twelve to forty feet deep, and furnish inexhaustible supplies of water. The stockmen have had no difficulty in getting large quantities of water in shallow wells on either side of the Pecos river, some of which furnish water for thousands of head of cattle.

Very little effort has been made in the Texas part of the Pecos river country to get shallow wells, and where the effort has been made the success has been only partial. In Ward county, east of the Pecos river, and north of the Texas and Pacific Railroad, and along the lines of the main line of the Pioneer canal, wells have been put down at numerous localities and water found at various places and depths. The drift material is so thick over a great deal of the Pecos valley that wells would have to be sunk over one hundred feet to reach a water bearing stratum.

ARTESIAN WATER ON THE STAKED PLAINS.

It can be stated in plain terms that the conditions are not favorable for obtaining artesian water on the Staked Plains. What I mean by artesian water is water that will flow at the surface when a water bearing stratum has been penetrated from above.

As it is believed that all flowing wells are caused by hydrostatic pressure, it is an indispensable requisite that a water-bearing stratum which will produce artesian water must be inclosed between two other beds impervious to water, and that it shall reach the surface at some place topographically higher than the locality at which the boring is to be put down, and that the catchment exposure shall be sufficiently large to collect enough water to saturate the water-bearing stratum.

A brief reference to the geology of the Staked Plains will show that any water bed which could possibly furnish flowing water on them must have its source beyond the western boundary of the Staked Plains themselves.

The following section of the strata of the Staked Plains, made at Mount Blanco, will show that there is no impervious beds surrounding a water-bearing stratum, belonging to this strata, and if the other conditions for artesian water were present, this condition, which is absolutely necessary, being wanting, no artesian water could be expected from the Staked Plains strata.

SECTION.

12	Soil	8 feet
11	Limestone, hard	2 feet
10	Sandstone	3 feet
9	Stalactitic limestones	4 feet

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8	White calcareous sandstone	4 feet
7	White sandy clay	30 feet
6	Chalk	4 feet
5	Packsand	20 feet
4	Chalk	8 feet
3	Greenish sandy clay	30 feet
2	Red clay	2 feet
1	Reddish clay	30 feet
	Total	145 feet

Below this is the water-bearing stratum.

Again, the water-bearing stratum of the Plains, at the place where it is exposed at the surface on the north, is not high enough to force the water out on the top of the Plains anywhere to the southward. The water that falls along the mountain range on the west and is taken up by the same strata as that of the Staked Plains, does not pass under the high plateau of the Plains, as that strata is entirely cut in two by the Pecos river In places on the high plateau of the Plains the water very often rises several feet in the shallow wells. The cause of this is that the stratum of sand and gravel overlying the water bed, becomes impervious to the water by precipitation of Carbonate of lime which fills up the spaces between the pebbles, and when this bed of "hard pan" is penetrated the water is forced upward and stands several feet above the bottom of the well. In very shallow wells along the line of the Texas and Pacific railroad, the water often rises to within a few feet of the surface.

The flowing wells reported on the Staked Plains are produced by the same causes. None of them are on the high plateau, but are in the canyons, and above the point where the canyons have cut their channels entirely through the Plains beds.

The next probable source of artesian water for the Staked Plains would be in the Triassic beds, which underlie the entire area of the Plains. These beds have the same dip, from northeast to southeast, as that of the strata of the Plains, and are very uniform in structure and composition throughout their entire extent. There are beds in this formation that would be good conductors of water. They crop out along the northern and western boundary of the Plains, and any water that might pass under the Plains would have its source along this outcrop. The top of the Plains where this outcrop occurs is from two to three hundred feet above the Triassic beds, so all that distance would have to be overcome before the hydrostatic pressure would bring the water to the surface. Therefore there is no probability that these beds would furnish artesian water for the Staked Plains.

The next beds underlying the Plains, and extending beyond their western and northwestern boundaries, are the Permian.

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The Permian formation is over two thousand feet thick east of the Plains, but its thickness west of them has not been determined, only the upper beds being exposed in that district

The dip of the Permian strata on the east side of the Plains is to the northwest, while on the west side it is to the southeast

There are some water-bearing beds in this formation, and they might be a source of artesian water supply were it not for the fact that the strata along the entire western side have been partly cut through by the Pecos river, and the upper beds on the northern side by the Canadian; but this being the case, there is no hope that flowing water can be obtained on the high plateau of the Staked Plains from this source. Again, all the clays and sandstones of the upper Permian beds are highly impregnated with salt and gypsum, and even if water was obtained on the Plains from this formation, the probability is that it would be so heavily charged with these salts as to render it unfit for use.

The beds below the Permian on the Staked Plains are the Carboniferous. This formation is over —— thousand feet thick on the eastern side of the Plains, and a section of fifteen hundred feet has been made of the western side. The dip of the strata on the eastern side is to the northwest, and on the western side it is toward the southeast. The rocks of this formation compose the high mountain range on the west, and if the other conditions were favorable water might be obtained in this formation that would come to the surface on the Staked Plains.

The Carboniferous strata west of the Plains has not been studied sufficiently to enable me to correlate it with the same formation on the eastern side, but enough is known to say that it is certain that only the lower part of the formation is seen in the mountains on the west. The depth, therefore, at which that part of the formation would be reached on the Staked Plains would be several thousand feet, so deep that it would be practically impossible to get water on the Plains from that source.

There is a popular notion that there is an immense sheet of water under the Staked Plains which finds its source in the mountains of Colorado; but there is no evidence of this, and if there was, the water would be at such a great depth that it could not be reached.

After as thorough an examination of the matter as I have been able to give, I do not hesitate to say that it is extremely improbable that artesian water can be had on the Staked Plains.

ARTESIAN WATER WEST OF THE PECOS RIVER.

The conditions for artesian water in the country situated between the Pecos river and the base of the mountains beyond are much more favorable than on the eastern side of the river. At places there are anticlinal axes running from the foot of the mountains toward the

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river, and in the troughs between these folds water may be had at various depths and in several of the formations.

At Toyah, flowing water was found at a depth of 800 feet in the Carboniferous strata. At that place the Cretaceous overlies the Carboniferous, and in that formation a bed of water was also found, but which would not flow at the surface, although it rose quite a distance in the well. It is probable that there are places where this water will flow at the surface.

There is a flowing well at Roswell, in New Mexico, that comes from the bottom of the Tertiary, or the upper part of the Triassic.

There are about twenty flowing wells at Pecos City, west of the Pecos river. The water is abundant, and comes from a depth of from one hundred and fifty to two hundred feet. The probabilities are that the water comes from the Quaternary. At least it comes from the drift in the old river channel.

No prospecting for artesian water has been done away from the railroad, and it is more than probable that large amounts of water will be found at various depths in many localities when proper effort shall be made. The whole country is so covered up with drift from the mountains that it is almost impossible to determine anything about the underlying formation, and the consequence is that one is as liable to sink a well at the apex of the anticlinal as in the trough. In the latter case the water would be reached, while in the other the chances are that it would be a dry hole.

I see no reason why the water-bearing stratum at Toyah might not be reached at Pecos City at a depth of less than two thousand feet.

MINERALS.

The only minerals of any economic value in the district over which I traveled this year is gypsum and common salt.

The gypsum is in heavy beds in the upper part of the Permian formation east of the Staked Plains from the line of the Texas and Pacific Railroad to the north line of the State.

West of the Pecos river, near the line between Texas and New Mexico, in the Permian formation there are heavy beds of gypsum, which are in all probability a continuation of the beds found east of the Staked Plains.

The uses to which gypsum is applied need not be discussed in this paper.

SALT.—The deposits of salt seen during the present year's explorations were in the shallow lakes on the eastern edge of the Plains, and in the country west of the western escarpment.

Just north of the line of Texas and Pacific Railroad,—— miles east of Marienfeld, there are —— lakes that at the time of our visit were incrusted with very fine white salt to the thickness of ——— inches.

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These lakes were about ——— acres in extent, and at the time of our visit thousands of pounds of salt could have been had for the picking up.

I do not see why the gathering of this salt would not be a profitable enterprise.

THE TRINITY SANDS AS A PROBABLE SOURCE OF ARTESIAN WATER SUPPLY.

The name Trinity Sands has heretofore been made to embrace a much thicker strata than is intended to be covered in this report. It has been made to include all the strata from the top of the Paluxy Sands to the lowest sand beds overlying the Paleozoic area on the east. What I intend to call Trinity Sands in this paper are the sand beds below the alternating beds as seen a few miles east of Milsap, in Parker county. I believe that it is possible to separate the Trinity and Paluxy sands, and that in particular descriptions they ought not to be confounded or even put under the same name.

The Trinity Sands of Eastern and Central Texas are known to furnish abundant supplies of artesian water. The artesian water at Fort Worth, Dallas, Waco and Austin is from this bed. It is an important fact to determine whether or not the same sands of the western district will be as good a water producer as the eastern field.

The Trinity Sands along the eastern escarpment of the Staked Plains is co-extensive with the Cretaceous formation, and I do not know of a single locality from San Angelo to the Double Mountain Fork where the Cretaceous occurs that the Trinity Sands are not present.

There are two reasons why the western beds would not be as great water producers as those in the eastern district.

The first is, that the exposures are generally on the face of the high escarpment, where very little water would be taken up during the time of the rainfall. These beds are generally not the lower beds of the escarpment, and the sands that have washed down do not form beds from which the water falling on them would be taken up and conducted into the bottom of the stratum; and the escarpment is not at right angles with the dip, so as to take up all the water that falls, but is almost parallel with the dip, and the water is as liable to run away from the beds as toward them.

The second reason is, that the stratum is cut across in so many places by the canyons that no very great area could be embraced in the supply territory.

Along the northwestern border of the Cretaceous formation, which would naturally be the receiving basin, the waters from which would be carried by the dip of the Trinity Sands to other localities, the formation is covered up entirely by the newer beds at the top of the Staked Plains.

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A line drawn from the eastern escarpment of the Staked Plains, where that escarpment crosses the Double Mountain Fork, to the Horsehead crossing on the Pecos river, would represent the northwestern limit of the Cretaceous formation in Texas. But the formation along that line is now entirely covered. During the deposition of the earlier beds of the Tertiary which finally covered the entire Staked Plains, there was a high escarpment of Cretaceous along the line indicated, and that escarpment was the seashore of the then Tertiary seas and against which these lower Tertiary beds were deposited. Northwestward from that old shoreline these earlier beds of Tertiary are known to be full of water, and it is more than possible that the Trinity Sands along that old shoreline may become saturated with water from that source. If that be the case, then they will be good water-bearing beds to the southeastward, where the strata has not been cut into by the canyons at the head of the North Concho river.

It is highly probable that the water from the large springs at the head of the Concho rivers, Dove and Kickapoo creeks, comes from this source, and it may be that the large spring south of the Llano and Mason Paleozoic area are supplied in the same way.

The water in the head of Dove creek, in Tom Green county, reaches the surface through the upper part of the Caprotina limestone, and San Marcos Spring reaches the surface through the Arietina clays, yet the water in each may have the same source of supply.

AGRICULTURE.

In discussing the agricultural possibilities of any country there are three principal things to be taken into account. Fertility of soils, length of seasons, and amount of rainfall, and where the rainfall is not sufficient and at proper seasons, the possibility of obtaining water for the purpose of irrigation. A general statement in regard to these subjects is all that can be attempted in the present report.

SOILS.—The soils of the high plateau of the Staked Plains is mostly red sandy loam, and where the vegetable matter has been mixed in sufficiently large quantities with the soils, the upper part is black. The origin of this soil is evidently from the broken up and disintegrated strata of the Cretaceous and the Triassic. The great fertility of these soils has been proven by actual test, and is shown in the abundant crops that have been grown there for several years, consisting of wheat, oats, barley, corn and cotton, as well as millet and sorghum.

These soils are especially adapted to the growing of wheat, and the time is not far distant when this immense Plain will be the great wheat producing region of the State.

Fruits of all kinds where tested have done well, especially peaches and plums. Grapes and berries grow luxuriantly and produce excellent crops of fine quality.

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RAINFALL.—The most of the Staked Plains is in the belt known as the arid region, which is to be understood as a country where the rainfall is not sufficient to produce crops.

It has been estimated that where the rainfall was less than twenty-two (22) inches per annum it was too dry for a successful agricultural country.

The average rainfall on the Staked Plains is put at twenty (20) inches per annum, and yet good crops have been matured. There are two reasons why this is possible; one of them is, that the greatest average rainfall is in summer, during the season of growing crops, while the time of droughts is in the winter and spring. The second reason is, that there is a stratum of water-bearing sands at various depths underlying the entire area, and by capillary attraction this water is brought within reach of the rootlets of the growing crops. Any time during the growing season moist earth can be found only an inch or two below the surface at almost any given point on the Plains. This sub-irrigation will mature crops even if the rainfall is below that which is ordinarily required for the production.

Agriculture west of the Staked Plains is entirely dependent upon irrigation, and will be considered under that heading in this report.

IRRIGATION.

The subject of irrigation in Western Texas demands a more extended consideration than it will be possible to give in this brief resume, for the success or failure of agriculture in the western part of the State is dependent upon the possibility of getting water in sufficient quantity and purity.

There are three possible sources of supply, and there are very few localities in which one or the other could not be made available—natural streams, wells (either shallow or artesian) and storage reservoirs. Each of these might be supplemented by one or the other where possible, and the area brought under cultivation increased considerably at such localities.

While it is true that on the Staked Plains, and in many places east of them, good crops can be raised without irrigation in ordinary seasons, it is nevertheless in all seasons a most valuable auxiliary, and there are seasons when it becomes a vital necessity; and the importance of being prepared for such seasons becomes apparent when we remember that it is impossible to foresee when they will occur. West of the Plains, however, the situation is entirely changed, for there irrigation becomes essential at all times, for on it successful agriculture is utterly dependent.

In the region east of the Staked Plains there are many streams of water that would furnish water for irrigating purposes, yet few of them have been utilized. The Conchos, San Saba, Colorado and Brazos

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rivers with their tributaries might be made available for irrigating the broad valleys found along their several courses.

The Concho rivers have been used to some extent, as has also the San Saba river, but not nearly to their full capacity.

There are a great many small streams and springs where the water might be utilized for small areas, at very small cost, very often at the cost of constructing a canal for a short distance, and at other places by the additional cost of building a small dam across the stream at some suitable place, so as to bring the water to a level with the ground to be irrigated.

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REPORT OF MR. THEO. B. COMSTOCK.

A Preliminary Report on parts of the counties of Menard, Concho, Tom Green, Sutton, Schleicher, Crockett, Val Verde, Kinney, Maverick, Uvalde, Edwards, Bandera, Kerr and Gillespie.

INTRODUCTION.

The area traversed in 1891, with the exception of a small portion hastily crossed in going from Austin to San Angelo, is occupied almost wholly by strata of the Cretaceous period. The complication of structure and the variety of rock stages which characterize the Central Mineral Region, are, therefore, absent from this tract. By selecting a route less tortuous and aiming to follow out one of two well marked horizons, it would have been possible to obtain a practically uniform topography and to reach conclusions widely different from those which our observations now justify and require. The execution of the survey being left to the writer in large measure, and the reconnoissance being necessarily extended over a vast area, an attempt was made to so shape the course as to include the widest possible scope of structure and the most important features of the geologic history of the region.

There have been honest differences of opinion concerning the geologic changes which have taken place in this little known region, and it was thought desirable to obtain some authentic evidence by instrumental surveys. The writer of this report has been forced to adopt opinions not in strict accord with the conclusions of one or two workers, chiefly by reason of a most intimate study of the rock-masses of the Central Mineral Region, and by the running of instrumental lines of section through this particular area. It being necessary for the purposes of the Geological Survey to gather information concerning the mineral and other natural resources of the counties in the title of this report, it was deemed wise by the State Geologist to have this reconnoissance conducted by one who was familiar with the adjoining territory. This will explain both the attempt on the part of the writer to contribute facts upon a question not yet beyond controversy and his inability to discuss these facts from the standpoint of a specialist in paleontology. In so far as the fossils may be required to settle particular questions, the conclusions must here be held in abeyance, except where they may be properly used to correlate beds not widely separated geographically.

The final results of this survey must be left in a great degree for a future publication; for although the topographic data have been carefully plotted upon a large scale and prepared for engraving, much detailed study of notes and collections remains to be done. In this preliminary report it is only possible to touch upon such salient features

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as were worked out in the field or defined by the maps in a striking manner. As a consequence but little of the argument can here be presented, and the most that can be promised is a conscientious effort to divest the facts of any garb of mere personal opinion.

The object of the present report being largely economic, it is mainly devoted to a consideration of the commercial possibilities of the region.

I.—The General Geologic Section.

The rocks which lie at surface in the counties immediately bordering the Central Mineral Region are of Lower Cretaceous or Jurassic time. The settlement of the real horizons of the beds must be relegated to the specialists who are still debating the question. It is sufficient for our immediate purpose to warn investors that, in any event, no valuable deposit of coal or lignite may be expected within this range, although worthy people have proposed boring to test the matter. All the important lignite layers lie in a geologic position considerably above this. There is much difference, however, in the contacts at the edge of the Central Region in different localities.* Upon the east and southeast the Cambrian and Silurian strata are in direct contact with the Jura-Cretaceous; farther westward the Carboniferous, and still farther the Permian rocks, lie directly beneath higher Cretaceous strata, speaking generally, until, in Tom Green county, south of San Angelo, the passage from Permian or Permo-Triassic to Cretaceous is direct, without the intervention of the Jura-Cretaceous. Continuing the section southward to the Rio Grande, successively higher Cretaceous beds are encountered, thickening rapidly and overlapping like shingles upon a roof. The same relations are apparent in higher beds down the Rio Grande from Del Rio to Eagle Pass and across the country from Del Rio to Spofford, although this latter course is more nearly on the strike than on the dip of the strata.

The geologic history of the region under review is very interesting, although its study reveals a different record from what cursory observations would lead one to infer. The evidences which have been mentioned in previous reports by the writer, of shore lines bordering the Central Mineral Region, are as plainly depicted in successively retreating repetitions through the Cretaceous series southward. The gradual thickening of the strata seaward and the overlap at the shoreward edges, are marked features which cannot be mistaken when checked off at frequent intervals along continuous lines of accurate leveling. This is particularly observable in the course of Devil's river

*It is this very significant fact which has had much to do with the writer's belief that the Central Mineral Region was a land area during a large part of the Cretaceous time. This opinion, however, was formed and announced partly upon other grounds before the work of 1891 had brought to light these facts in all their extent.

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in Sutton, Crockett and Val Verde counties, where the grade is not sufficient to overbalance the thickening of the strata.

The great water divide which separates the Colorado drainage from the southward flowing streams has not received the attention it deserves from geologists. As a mere topographic landmark it is remarkable, but when viewed as a structural boundary, it will repay very careful scrutiny. A hasty glance fails to indicate any connection with earlier rocks than the Cretaceous, except at the northwest of our area, in Tom Green county, where the Permian beds are exposed; but the evidence of the existence of a pre-Cretaceous fold throwing the earlier strata above the shore-line of the Cretaceous sea are apparent upon closer examination. Hints of the near approach of the pre-Permian, perhaps even Silurian, members are not wanting further east, and meagre exposures of granite have been reported by two members of the Texas Survey from near the line between Menard and Schleicher counties. In Val Verde county, west of Devil's river, a complicated ridge of jumbled strata of Carboniferous or Permian age forms a barrier against which the Arietina beds were laid down without subsequent disturbance. These areas of uplift are closely parallel with those which I have heretofore shown to be unmistakably pre-Cretaceous in the Central Mineral Region; and the later basaltic outflows seem to have used these very lines of weakness to some extent.

There is a question regarding the age of the basaltic outbursts. I am not yet prepared to speak conclusively upon the subject. The most northern ejections in Uvalde County follow most closely the pre-Cretaceous line of uplift, and these protrude into strata usually considered Lower Cretaceous. My observation is too limited to deny the occurrence of such igneous intrusions in the Upper Cretaceous, but the best judgment from the facts known to me is that the greater part of the basalt was contemporaneous with the deposition of the Lower Cretaceous strata. This opinion is, however, confessedly wavering from lack of detailed study of many exposures.

II.—Topographic Features.

The topography of the Cretaceous area is distinctive and pronounced, a characteristic example of simple drainage erosion carried to a numerical extreme without widespread denudation. To express it otherwise, the results are those accomplished by myriads of streams of small extent, which have cut deep and narrow canyons, leaving innumerable peaks, buttes and "hog-backs" in the intervening spaces. Thus the plateau levels corresponding to successively exposed hard layers are extensive, but so badly cut up by the ramifying streams that it is impossible to travel across them except by frequent ascent and descent of steep inclines. This peculiarity gives to one following the valley roads of the country only, an idea about as erroneous as is obtained by one

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who pursues the cross-country course, although either one will be liable to regard the region as more complicated in structure than it really is.

There is an individuality to each of the separate river basins, which might at first seem to be due to causes wholly independent of the rock masses, but a study of the strata leads to a contrary conclusion.

The Concho, San Saba and Llano valleys are striking examples of the influence of geologic structure upon topography. These three rivers flow in courses not widely diverse; the Concho and San Saba are coerced largely by conditions antedating the Cretaceous, but subsequent to the Carboniferous period, the general course of the Llano being guided largely by much more ancient structure, in large degree of Burnetian time. The Pedernales, the Guadalupe in part, and perhaps the Medina to some extent, occupy intermediate positions between the foregoing and the southward flowing streams, which flow down the grade of the retiring sea bottom of Cretaceous date. Occasionally the effect of earlier events, barely obscured by Cretaceous deposition, are visible in the windings of the last group of rivers, and the influence of the basaltic ejections in turning the courses of some of them locally is very evident. In some places the changes in the stream courses are inexplicable until traced to causes which would escape notice without close examination of the geology for many miles upon all sides.

In general, it may be stated that the drainage of the Cretaceous area is far less affected by post-Cretaceous movements than by the floor left by the retreating sea. But it must be remembered that this retrograde movement was not along an east west line, except for a limited distance, but rather in an irregular curve partially surrounding the Central Mineral Region. This, at least, is the view held by the writer after thorough instrumental work over that portion of the field most important to understand. It is fit to remark here that one or two able workers who have made general reconnoissances over portions of this and adjoining territory are opposed to my conclusions. The facts have, therefore, been collected with diligence and with a degree of accuracy beyond what is customary in the early stages of geologic work. The topography is a factor of great import in such investigations, for which reason our work in that direction has been minute along the lines of geologic section. The complete contographic representation of the border area must await the completion of the field work undertaken by the United States Geological Survey, an enterprise too ambitious for this Survey at present.

III.—Agricultural Possibilities.

The pastoral and agricultural capabilities of the major part of the region are by far greater than has been generally appreciated. Much of the area which is now neglected or given over to grazing can be

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eventually utilized for tillage. In the river valleys irrigation is perfectly feasible, and in many places where the streams are dry at surface there is an abundant supply of water not far below, throughout the year; windmills and "water-holes" ("tanks") now supply the needs as they exist, but a very much larger population and a materially increased productiveness will follow the advent of the steam pump, as it has already in other similar cases where capital has been freely expended.

A beginning in gravity irrigation has been made along the upper reaches of the Concho, in Tom Green county, but almost wholly upon the immediate flood plain of the river. There is a broad tract of prairie between San Angelo and the divide between the Concho and Devil's river, as well as through nearly the whole valley of the latter stream, which can be very readily converted into a fertile district by means of simply constructed ditches and reservoirs.

The region farther northeast drained by Lipan and Kickapoo creeks, now presents one of the most attractive and thoroughly watered grazing districts in Texas, and when necessary it will require but the minimum of labor to turn it into an agricultural tract.

So in the more limited environs of the southward flowing streams between Devil's river and the Nueces, excepting the country lying between Las Moras valley and the divide west of the Nueces river, which cannot be easily cultivated.

The comparatively barren highlands between the canyons of the larger southward flowing creeks cannot ordinarily be rendered tillable at any cost within reasonable limits, but these will always afford excellent pasturage and they are particularly well adapted for sheep husbandry. Such is the character of the greater part of the region traversed by the Nueces and Frio rivers where our line has followed or crossed them, although the aggregate acreage of tillable land along these streams is really very great, owing to their numerous ramifying branches with the incidental alluvial bottoms of great fertility.

Along the lowlands bordering the rivers, especially those flowing southward, there are extensive native groves of noble pecan trees. Nowhere could the cultivation of this crop be more successfully and profitably undertaken. This is especially the case in the canyons of the Devil and Nueces rivers. The Rio Frio, where the writer is familiar with it, is more favorable to the cypress. There are probably nowhere in the southeast such gigantic pecans as those which abound in the Nueces canyon from below its mouth to Barksdale and beyond, unless it be in the Devil's river canyon. But little effort has been made to assist nature by planting, nor has this been necessary, in fact. The thrift and contentment of the honest inhabitants of this region is proverbial, and the country might well support many more by this one industry of pecan growing.

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IV.—Water Supply.

With the geology what it is, a more favorable arrangement for the distribution of the water supply than that which exists could hardly be imagined. The Devil's, Las Moras, Nueces, Frio, Sabinal and Medina rivers flowing southward, with smaller intervening streams, all start from springs suddenly emerging in rocks of nearly the same horizon. Wells bored at various points between these springs and the very similar ones which feed the northward flowing streams across the divide—the South Concho river, Lipan and Kickapoo creeks and the South Fork of the Llano river—give no uncertain record. From these it appears that a vast body of underground water lies like an overflowing lake beneath this great divide The fact is all we can mention in this brief review, but it indicates much of geologic importance which may be discussed in our final report.

In questions of underground water supply the geologic structure is a very essential factor, whose relation to artesian possibilities is of vital moment. The arrangement of the strata in this region is not only admirably adapted to the collection of the rainfall of the district itself, but it affords an extensive catchment area and a well formed storage basin. Judging from what my own observations teach concerning the proximity and relations of the older rocks, and from a comparison with the known conditions further east, there appears good warrant for the belief that deeper-seated and more extended sources of supply are concerned in the filling of the reservoir in question. The topic is, however, too broad for full treatment in these pages. Complete instrumental data have been collected, and the results of the investigation will soon be forthcoming. Carefully prepared sections will be necessary to clearly illustrate the situation.

Artesian Water.

The conditions needed for the ready supply of water in the artesian wells are an extensive catchment basin, a porous collecting stratum between two retaining layers, and an outlet at a point where the pressure is less than at the surface of the reservoir. These conditions are all fulfilled save the last over the largest part of the region we are now considering. In some few places, chiefly where springs are abundant enough to make artesian water unnecessary, it might be feasible to secure flowing wells, but the reservoir is usually too low to make this possible unless it be in the southern portion of the tract. There the pressure is not usually sufficient to bring the water to the surface, and in some districts it cannot be obtained by boring even to great depths. Possibly, however, by going much deeper than has yet been attempted, the deeply buried reservoir might be tapped at a point of high pressure sufficient to elevate the water within pumping distance of the surface.

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We may judge better of this when the geologic section is worked out in detail. How well this is done must depend largely upon the funds available for office work in this division of the Geological Survey.

V.—Mineral Resources.

The Cretaceous strata, aside from the building stones and materials for lime and cement manufacture, are not usually regarded as prolific of economic value, although many are prone to look for gold and silver in all new countries. We shall see that there is enough variety in the deposits of this territory, however, to give promise of reward to well directed mining industry in several important directions.

ORES OF METALS OTHER THAN IRON.

Within the border area, including the greater part of the thirteen counties of the fourteen (Gillespie excluded) named in our title, there is little possibility of discovery of valuable ores of gold, silver, tin, lead, zinc or other high priced metals. Copper ores, such as may possibly occur in Permian strata near the edge of the district, have not come under my own observation, and these rocks are practically all within the field of operation of another member of the Survey.* The veins which have been found in conjunction with the basaltic dykes in Uvalde county, as on Turkey creek and near Montell, have been supposed to carry ores of silver. Very small amounts of galena and copper pyrites have been discovered in such situations, and it is in these places that discoveries of the kind may be anticipated, if anywhere in the region. The prospect is not very favorable, the indications being lean and unpromising, as far as they have been tested heretofore.

Deposits which may become valuable in the manufacture of aluminum are not wanting, but in the present stage of production they are not liable to be called into play as the basis of any considerable industry.

IRON ORES.

The ores of iron which occur in the district are wholly unlike those described in the previous reports from the Central Mineral Region. They may be conveniently grouped in three classes, distinguished by their modes of occurrence.

To the first class belong the bedded masses of yellow and red ochres, which appear to have been formed along the shores of the earlier Cretaceous seas by the degradation of the pre-formed rocks of the Central Mineral Region type. These outcrop more or less regularly at definite horizons near the base of the so-called Cretaceous system, but they are only occasionally of such a character as to merit attention as commercially valuable ores. Frequently they are too highly siliceous, and

*Prof. W. F. Cummins, Geologist for North Texas.

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rarely contain enough iron to make them suitable for economic purposes.

The second class is more restricted in distribution, but more liable to have industrial application, being of higher grade, usually much less siliceous and possessing qualities of more comprehensive utility in the arts. I am not prepared to assert that these are invariably of equivalent origin, but, for the most part, they represent a different history from that of the earlier formed basal ferruginous beds. Their mode of occurrence is ordinarily dissimilar, savoring of the vein type, and, as a rule, there are evidences more or less definite, of a connection with ancient igneous eruptions. In some cases this is very apparent in the dykes of basaltic material which coincide with the ore bodies, but in other instances this feature is not well marked, and but little indication of such a structure is then afforded by the deposits, excepting the tendency of the outcrops to an alignment roughly parallel with the general courses of the distant igneous dykes. Of this last kind are the patches which have attracted much attention a little east of Del Rio. Near Montell, in Uvalde county, there is a number of well-defined dyke veins of this second type. Wherever excavations have been made in them their close relations to the basaltic outbursts are usually very evident. General Baylor, of Montell, has explored many of the veins and taken out quantities of the ochreous ores. The Montell Mine, three and one-half miles northwest of Montell, has yielded the best product thus far, but others are as promising and the material exists in abundance in this neighborhood. In places there have been slips, or faults, of slight movement where the basalt has intruded. As a rule, the iron ore is most abundant and valuable where the basalt dyke has had a cap of later limestone, and in many places the ore outcrops where basalt cannot be detected, although in crevices running parallel to prominent dykes in the neighborhood. The ore is limonitic, but of good grade, not usually highly siliceous, and it is probable that it will play an important part hereafter in the industrial development of Uvalde county. Similar deposits in equivalent situations occur in other districts, but the most prominent exposures are in the vicinity of Cline, on Turkey creek, and in the neighboring country, and as above stated, around Montell. The best places to prospect for them will be in the region occupied by the basaltic dykes.

The third class of iron ores includes the nodular or concretionary bands which traverse the sandstones of the coal area, in positions varying from twenty feet to one hundred and fifty feet above the coal. The value of these layers as indicators in borings made in search of lignite may be considerable, but, for the most part, the commercial worth of the iron ore itself is not very great. The product can rarely be obtained sufficiently free from silica for profitable use. Akin to this

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class of ores are the concretions which occur in certain layers among the Arietina limestones, and at another higher horizon of the Cretaceous outcropping south of Cline postoffice near the summit of the hills. The ore is globular, varying in size from that of a pea to balls one or two inches in diameter, the bullet size being most common. Perhaps, if these could be gathered in sufficient quantity, they might become of some value as iron producers, but there are probably no localities where the cost of collection would not preclude their industrial employment.

With the immense deposits of choice hard ores and the limonitic products of the Central Mineral Region so near at hand, it does not seem reasonable to look for the upbuilding of any very extensive iron smelting business in this region. As a means of local supply for a limited product, there may eventually be demand enough to stimulate mining in a degree, but there is much more prospect that the Del Rio and Montell mines will be called upon to supply a market for raw material to be used as paint, for which much of the ore is well adapted.

KAOLIN.

The region of the vein of iron ores is practically the area within which the deposits of kaolin occur, and as in the former case, the relations to the basalt dykes is unmistakable also in the latter accummulations. There is, however, a peculiar tendency of the kaolin banks to conform to the drainage courses, i. e. to lie in local basins. More study will be required to determine whether this apparent feature is strictly real; although the best deposits of kaolin are known to be in situations near the basalt where there has been the best opportunity for the silting action of incipient streams. There is considerable variation of quality, the best known workings being those which lie off the main road from Barksdale to Leaky, in Edwards county, about four miles from the latter town. Here the product has been mined from pits dug fifteen to twenty feet through the overlying gravels. Tests to be made in the chemical laboratory of the Survey must be awaited before a full report can be made of the value of the deposits. It is very probable that careful search over the area of basaltic outbursts will be rewarded by other discoveries of this material. I have taken samples from the Nueces valley not far below the point where the basalt dykes cross that stream, and from similar situations elsewhere.

It would seem that both the kaolin and the ochres are direct products of decomposition of the igneous intrusions, the former being usually or commonly reassorted by aqueous action and transported to greater or less distances from the point of origin, the latter being mostly formed in the position in which it now lies, or occasionally in beds not so far removed from the original locas as the kaolin, which would be more easily transported, of course.

The kaolin is very well placed for economical working, and if it be of

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commercial value, there will be little difficulty in obtaining it in abundance. At present, transportation facilities are inadequate for any considerable industry, and the best deposits are near the summit of very dry ridges. A large quantity was mined several years ago, but for some reason the property has been abandoned, temporarily it is claimed by residents in the district.

ASPHALTUM.

The ashpaltum belt, or basin, is also roughly coincident with the area of basaltic outcrops, but the deposits are more narrowly restricted than the other economic products which seem to be more or less intimately associated with the eruptive tracts. I have no knowledge of any discoveries of this material outside of Uvalde county. The only tract which came under my personal inspection forms part of what is known as Debrill's ranch, on Turkey creek, about three and one-half miles below Cline. Here a tract of some twenty acres exposes what appears to be a thick layer of Cretaceous rock highly charged with bituminous matter. The rocks appear at first sight to be much disturbed, but closer inspection shows that a semi-fissile or roughly concretionary structure has been induced by weathering and by the irregularly crowded fossils which make up a large part of the limestone. As if produced by the organic matter of these fossils, the porous rock is also filled with the asphaltum which oozes out through the crevices and upon surfaces exposed to the sun. Freshly broken rock from greater depth show less of this at first, but it soon becomes apparent on exposure to the dry air. The percentage of the asphalt is large enough to make it profitable to handle the product commercially, although but little as yet has been attempted in this direction. This deposit has all the prominent characteristics of the famous beds of the Val de Travers, and from its mode of occurrence here, it is almost certain that continuations of the bed will be found by intelligent search. A very similar outcrop is known further south and reports have come in of others in different directions. This is only another instance of the value and necessity of accurate knowledge of geology in systematic exploration for mineral wealth. By familiarizing oneself with the beds above and below this horizon and tracing them where they lead, no doubt one might readily ascertain the exact continuations of these deposits and unearth extensive accumulations of the same material. A good practical geologist familiar with such products should have little difficulty in pointing out such places in which to mine the product.

COAL, OR LIGNITE.

The lignite* field, so far as it lies within the limits of our survey of 1891, is confined to a comparatively narrow tract extending across the

*The term lignite is used here in accordance with the American usage classing all coals of later age than the Carboniferous as Lignite. E. T. D.

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Rio Grande from Mexico into Maverick county, Texas, north of Eagle Pass.† The lignite is of excellent quality, as a rule, and in many localities along the northern and western edge of the field it is well exposed for economical mining. It has been worked successfully in a few places near the surface and it has been discovered by boring or shafting at other points at depths varying from twenty feet and less to three hundred feet and more. The Hartz Mine has the most extensive development. This has yielded a large quantity of coal of good quality, although but crudely operated on account of the limited territory controlled by the owners, and because of the favorable exposure of the bed for working. There is, however, a little irregularity due to faulting, which has not given serious trouble. The proprietors have made borings farther east along the line of the Spofford and Eagle Pass division of the Southern Pacific railroad, near Olmos Station, where the lignite has been reached at a convenient working depth. The principal coal seam is a member of the undoubted Upper Cretaceous series. It is well exposed in gulches at the Hartz Mine, but is apparently cut off by a fault at the upper side, and dips rapidly southeastward, reaching a known depth of five hundred feet within a distance of a few miles in that direction. A number of shafts have been sunk near the line of outcrop between the Hartz Mine and the crossing of Olmos creek by the Spofford and Eagle Pass Branch of the Southern Pacific railroad. In some of these no good indications were found, but in all which were excavated far enough into the basin, the coal was struck. Owing to the erosion the seam is reached much nearer to the surface at some points than would be possible otherwise on account of the dip. Thus the Flossie and Breckenridge shafts, not far apart, are eighty and one hundred feet deep, respectively, owing to difference in elevation at the surface largely. At Thompson's ranch (Olmos Siding) the same bed was struck at one hundred and fifty feet, the level at surface being a little lower than at Breckinridge shaft upon the same property, and the dip balancing the gain. At McKenzie's, farther east, at a lower level topographically, the combined effect of dip and erosion has brought the surface within twenty feet of the coal. It is in this neighborhood that future operations are projected.

The coal has been successfully used by the railroad and for blacksmithing. Samples have been collected with care and the line of outcrop of the bed approximately run on the ground. Good indicators are beds of the nodular iron and a stratum of fossil wood, the last being about one hundred and seventy-five feet above the level of the coal.

†For courtesies extended and much valuable information, I owe grateful acknowledgment to Mr. J. Owen, of Eagle Pass, an engineer whose familiarity with the coal field is creditable to his zeal and excellent powers of observation. Our studies have verified his conclusions regarding the extent and position of the lignite beds and their relation to the intercalated iron ore layers.

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North of the line of outcrop of this coal field there is no possible chance of discovering it within the counties examined in 1891 by the writer.

BUILDING MATERIALS.

Many of the Cretaceous limestones are tough and hard. Some are inclined to weather irregularly and others turn dark upon exposure, but some most excellent building material may be obtained by care in the selection. Clays for brick manufacture and some for the more refined uses of pottery are available in the region of basaltic eruption, although some of these are highly charged with iron. The ingredients of Portland Cement are abundant in certain parts of the Lower Cretaceous series, more especially along the border of the Central Mineral Region. Many of the limestones burn free to a good quality of quicklime, although some of them contain larger percentages of magnesia than is desirable. For certain ornamental uses the limited outcrops of basalt may be serviceable, and certain of the hard limestones can be utilized as marbles when polished. Road material of excellent quality and material for ballasting railroad tracks are very abundant.

CONCLUSION.

There can be no need of particularizing as to the special advantages of individual counties in a report of this general character. So far as agricultural advantages are concerned, there is little to be said of one section which will not apply as well to another, and such local peculiarities as have already been noted will serve to indicate the particular industry which can be best maintained at given points. The one fact which most impresses one who sees this stretch of country for the first time is the real abundance of water within easy reach over all but a small part of the region. A district often regarded as wild and uninhabitable is found, upon inspection, to be peopled by a sturdy class of settlers, who are already reaping a good harvest, chiefly from grazing, but with possibilities of a liberal reward from investment in agriculture, and prospective opportunities for not a little in a mining way. The recent growth of this section, as shown in the increased population, the organization of new counties, the building of wagon roads and projecting of railroads, is based upon a substantial foundation of natural resources and it is not, therefore, surprising that orderly, law-abiding, home-making and progressive citizens have formed the very largest proportion of those who have entered upon the land. Nothing is now needed but the spread of a knowledge of the real situation to draw other thousands into a district which has, perhaps, more varied and attractive inducements than almost any other equal area even in the broad State of Texas.

Respectfully,

THEO. B. COMSTOCK,

Geologist for Central Texas.

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REPORT OF MR. W. KENNEDY.

INTRODUCTION.

The work of the Survey in East Texas during the season of 1891 was chiefly the determination of the different geological horizons found within that area. The examination of some of the lignite deposits of Wood county and a complete detailed examination and survey of Houston county were also made during the season.

For the purpose of locating the contacts and positions of the different geological horizons found within this portion of the State detailed sections extending from the Cretaceous marls in Kaufman county to the coast were made. The main line of sections, which commences at the contact between the Cretaceous marls and the base of the Tertiary, about three miles east of Terrell, Kaufman county, passes across the eastern portion of the State, in a generally south-easterly direction, ending at Sabine Pass, a distance of nearly 300 miles

Another section was made across the lower portion of Anderson county, through Houston county and ending at the Trinity river in Trinity county.

The main lines of the railways extending in easterly, south-easterly and southerly directions were used as the basis of these sections, but with the view of obtaining as accurate information as possible relative to the lay of the different deposits, as well as their comparative elevations and maximum thicknesses, zigzag lines, sometimes several miles in length, were drawn diagonally across the main line of levels.

The railway profiles used were: 1st. That of the Texas and Pacific from Terrell to Mineola, a distance of 46 miles. 2nd. The International and Great Northern Railway from Mineola to Tyler, 25 miles. 3rd. The Tyler Southeastern from Tyler to Lufkin, 90 miles. The scale of this profile was so small that considerable leveling had to be done by the Survey. 4th. The Houston, East and West Texas Railway from Lufkin to Corrigan, 24 miles. 5th. The Trinity and Sabine Railway from Corrigan to Colmesniel, 29 miles. 6th. The Southern Pacific Railway from Rockland to Sabine Pass, a distance of 103 miles.

In the shorter line across Houston county the levels used were altogether those of the International and Great Northern Railway.

The levels used on these lines are all based upon the average tide level of the Gulf of Mexico at Galveston, and may therefore be taken as accurate. The levels obtained by the Survey are partly instrumental and partly from barometric readings, and may be considered reasonably accurate.

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Geology

Throughout the region there is no serious want of conformity between the various geological divisions. On the contrary, they appear to graduate so easily from one to the other that it is often somewhat difficult to tell the exact line at which the actual change occurs. In most of the places where the contacts have been observed the exact limits of each are as yet approximations only, but the line will not in any case vary more than a few feet in either direction.

Throughout the greater portion of the area under consideration the overlying drift material has covered up the older formations to such an extent that the contacts between them are exposed at only a few places, chiefly in the few bluffs along the rivers flowing through the territory. They are also to be seen in a small number of the deeper railway cuttings.

Along the contact between the newer Eocene and the beds ascribed to the Miocene age there are indications at several places of extensive erosions having taken place prior to the deposition of the Miocene beds. These erosions appear to have the form of long, narrow arms of the sea or river channels, and are often several miles in length. The dip of the deposits occupying these buried channels varies slightly, both in angle and direction, from the beds forming the hills or shores of the channel. This variation does not, however, exceed a degree greater than from southeast to south, and may properly be accounted for by the action of tidal waters or rivers subject to overflow. Similar variations of dip and direction occur among the deposits forming the overflow lands of the present rivers.

The contacts between the overlying Quaternary gravels and sands and the underlying older deposits are, however, subject to no rule. These sands occur irregularly, both in areal extent and thickness, frequently lying upon the smooth surface of the bed beneath them, and then again filling up eroded depressions in the same beds.

While the whole of the details of these sections have not as yet been worked out it is believed that the following broad outlines of the work done are as nearly accurate as can be given until a thorough study has been made of the materials obtained during the course of the work. They may, therefore, be taken as approximately correct, and while all figures here given relative to the thickness and extent of any of the deposits may be looked upon as tentative only and subject to correction, it is believed that no great variation will take place between those given and those of the final results.

The relative thickness of the deposits found along the lines of the sections made are shown in the following generalized section:

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I.	Recent		20–30 feet
II.	Quaternary—		
	1. Blue clays—Port Hudson (?)	30	
	2. Gravels and sands—Orange sands (?)	60	
			90 feet
III.	Tertiary—		
	1. Pliocene		Doubtful
	2. Miocene		400 feet
	3. Eocene—		
	a. Middle	1300	
	b. Lower	250	
			1550 feet
IV.	Cretaceous—		
	In Richardson's well at Grand Saline		357 feet

RECENT.

Most of the rivers and their tributary streams crossed by the sections made, and elsewhere throughout Eastern Texas, are subject to extreme variations between high and low water marks. As a result of these extremes there are extensive areas of overflow lands everywhere along these water courses. Occasional bluffs of a height sufficient to stand above the high water mark occur close to the channel of the stream, but in places the overflows reach depths varying from a few feet to twenty-five and even thirty feet, and in some extreme instances the water has risen to forty-five feet.

The areal extent of these overflow lands cannot be given or even approximated, as they occur under all kinds of conditions and under different circumstances and vary in different years. Each main stream with its tributaries or drainage system is independent of all the others, and the width or longitudinal extent of the alluvial bottoms connected with it is governed by the conditions surrounding or forming the boundaries of the drainage area to which they belong. In many places the areas subject to overflow extend to a mile or a mile and a half in width, but throughout the greater portion of the country the width does not exceed more than a distance of three or four hundred yards.

The areas subject to these overflows are covered with a black alluvial soil. This soil is in many places thinly stratified or laminated, but in many localities shows a massive homogeneous structure. A section from the east bank of the Trinity river south of Hall's Bluff, near the confluence of Hurricane bayou and where the overflow areas are extensive, may be taken as typical of this class of deposits. The bluff formed between extreme low water and the elevation at which the overflow begins shows—

Thinly laminated dark clayey sand, with occasional deposits of dark blue clay averaging 2 inches in thickness, dipping at angles varying from 18° to 8°, gradually becoming shallower until at the top it is nearly horizontal . . . . . 14 feet

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In these soils roots and stumps of trees of modern growth are found, and along the margin of the lands thus subject to overflow there are numerous recent shells, chiefly of *Bulimus.*

Between the Gulf coast and Taylor's bayou, and extending north along the west coast of Sabine lake as far as Grigsby's Bluff, and thence in a narrow strip about two miles in width northward along Snow river to a point within four miles of the town of Beaumont, in Jefferson county, there is a tract of low, flat, marshy, sandy land, much broken by lagoons and bayous and smaller marine inlets. This region maintains a growth of marsh plants, and at Grigsby's Bluff as well as several other places along the river contains large deposits of shells of the genus *Gnathadon*, with occasional oysters.*

This has already been referred to the Coast Clays in First Annual Report, page 63, but is here placed with the Recent as being similar to the alluvium of Hilgard[I] and Lockett.[II]

QUATERNARY.

The general facies of the Quaternary deposits are orange, brown, red, yellow and gray sands and loams, occasional deposits of red and yellow clays and silts toward the north, and blue massive and laminated clays in the southeastern portion of the State, ferruginous and siliceous gravels, soft, much broken deposits of ferruginous sandstone, broken monolithic formed bowlders of white and gray sandstone, gravelly and ferruginous conglomerates and highly siliceous iron ores. The maximum thickness of these deposits has been placed at ninety feet, but this thickness exists at only a few places. As a general thing the deposits here classed as Quaternary are thinly and irregularly deposited and rarely exceed ten feet in thickness.

Structurally these Quaternary sands and gravels show a very irregular deposition and many of the sections seen show them to have been subjected to great variations in the conditions under which they were deposited. In places the sands are broken by thin, irregularly deposited fine ferruginous gravel. These gravel deposits usually appear as filling rounded and steep-sided depressions in the finer white or brown sands. Where the iron ore deposits occur the coarser gravels and pebbles show large quantities of ferruginous material throughout them, but away from these points the siliceous pebbles and gravels are the prevailing characteristics of the deposits. The siliceous gravel is very irregular in both extent and thickness, at places reaching from one to two feet in thickness and at others showing no more than a few scattering

* For other localities in which these shell mounds occur, see First Annual Report of Geological Survey of Texas, p. 64.

[I] Geol. of Miss., 1863, p. 201. [II] Third Annual Report Geological Survey of Louisiana, p. 203.

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pebbles, and is frequently wanting altogether. In areal extent these gravel deposits cap some of the higher hills and spread over the surface for a few acres, but the extent is usually small.

The areal extent of these Quaternary sands and gravelly deposits can scarcely be given in this report, but they may be assigned to the region of country occupied by the upper division of the Eocene deposits. They occur but rarely in the region in which the lower Eocene or Basal Clays are found, and their southern limit appears to be near the middle of the Miocene territory. Over a portion of the region occupied by the Miocene, these gravels and sands appear in places as outliers or fragmental remains of an extensive deposit reaching still further south; at some points on the Trinity river and elsewhere in Houston county, as lying beneath a covering of fine yellow sand or bluff loam and prairie soil, and at others they are seen capping the summits of the highest points of the country. The most southerly point at which these sands and their accompanying siliceous pebbles and conglomerates were seen was at Summit on the Rockland branch of the Southern Pacific Railway in Tyler county. The profile of the road at this point shows a steep-sided hill rising to an elevation of 500 feet and sloping off more rapidly to the north than towards the south. The hill is flanked on both sides by deposits of Miocene age, the southern side showing a gray siliceous sand and on the north the gray sandstones of the Miocene extend from near the base as far as Rockland on the Neches river.

The Quaternary capping of this hill, as shown in a cutting nearly three-fourths of a mile in length, are brown or pale red cross-bedded sands interlaminated in places by an irregularly lenticular shaped deposit of bluish brown clay and stratified ferruginous material, quantities of siliceous gravel and bowlders of conglomerate, the whole being capped by a purplish brown ferruginous sandstone which appears to be closely related to the conglomerates, as many of the blocks dug out in the formation of the railway have the two closely cemented together. These deposits appear to rest upon pale blue, brown and light green clays and sands.

Although this point was the most southerly at which any quantity of pebbles were observed, the brown sands with stray siliceous pebbles occur at several places nearer the coast. Two miles north of Seneca the brown sands are exposed nine feet and are associated with bowlders of gray sandstone. Fifteen feet of the same brown sand with small quantities of ferruginous and siliceous pebbles are exposed in a cutting near Hollister station. In this region the brown sand is intermixed with white and pink sands and in places assumes a mottled texture. Near Hyatt the same mottled sand is overlaid by three feet of yellow sand containing a few ferruginous pebbles.

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These deposits have for the present been assigned to the Orange Sands. Detailed sections have been made and are now being studied in relation to their proper position in the general section.

In the neighborhood of Beaumont and northward to Village creek, in Hardin county, there are some deposits of dark blue laminated clays and sands overlying a heavy deposit of gray clay. These probably belong to the later Quaternary and are of the same age as Hilgard's Port Hudson group. No fossils were found in these clays. The country is nearly flat, sloping only at the rate of two or three feet to the mile throughout the whole thirty-five miles, and very few sections could be obtained. The total thickness of these clays will not exceed thirty feet.

PLIOCENE.

No recognizable deposits of this period have been found along the line of any of the sections.

MIOCENE.

The series of deposits named Fayette Beds by Dr. Penrose, and described by him in the First Annual Report, page 47 *et seq.*, have been mostly referred to the later Tertiary or Miocene age.

These deposits overlie the upper division of the Eocene, are practically conformable to these beds and consist of thinly laminated blue and brown clays and sands containing great quantities of selenite crystals, massive brown sands jointed in various directions with crystals and masses of gypsum in the joints, black, gray, pale green, brown and white clays. These form the base of the deposits and are overlaid by massive and laminated gray sandy clays and clayey sands containing fragments of leaves, gray sands and sandstones containing quantities of opalized wood, leaves and stems and leaves of palms, etc., diatomaceous earths and lignites. In Polk county the gray sandstones are fossiliferous and are underlaid by a thin deposit of light gray fossiliferous limestone.

Areally these beds succeed the upper deposits of the Eocene and have their northern boundary, so far as yet defined, in a general northeast and southwest direction, beginning on the east side of Cherokee county, near the junction of the Atoi creek and Angelina river, passing across Cherokee about a mile south of McBee school house, and thence a little south of Alto to the Neches and crossing into Houston county about five miles south of Weches. From this point the boundary runs west for a few miles and then turns rapidly towards the south, passing Crockett about half a mile south of the town. It then turns west for nearly four miles and thence in a nearly southern direction almost parallel to the course of the Trinity river as far as Alabama Bluff, at which place it crosses into Leon county.

The southern boundary of these beds have not yet been definitely

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traced, but where the line of the section crossed the country they were found as far south as Village creek in Hardin county, where they were succeeded by an overlying clay which has been ascribed to the later Quaternary or Port Hudson and to the Coast clays by Dr. Penrose. These beds with the accompanying sandstones are also found at Phelps, on the International and Great Northern railway in Walker county, and Livingston in Polk county. The total thickness of these deposits has been placed at 400 feet.

The fossiliferous limestone found in Polk county is probably the first of the class known to exist in this portion of Texas.*

The plants found in these deposits are obtained chiefly from the gray and white sandstones.

The most characteristic feature of these deposits is a heavy belt of gray and whitish gray sandstones extending from Rockland on the Neches to Riverside on the Trinity river, in the district covered by this report, but is also found lying both east and west of these rivers.† These sandstones apparently increase in width as they extend southwestward. The area covered by them and their associated diatomaceous earths at Rockland is about seven miles wide, and at the crossing of the Trinity at Riverside the area has widened to over twenty-five miles, and broken deposits extend to Lovelady and Paso, about eight miles further north. These sandstones are generally stratified. The strata are from two to four and even more feet thick near the base, but become thinner and more slabby as well as whiter towards the summit. They are more or less fossiliferous throughout, the fossils found being altogether the leaves and branches of trees and other land plants. In the flaggy upper deposits the most prominent remains found are those of some marsh grasses or sedges and sabal, some of the latter having a spread of over four feet.

Near the base there are heavy deposits of diatomaceous earth, locally known as chalk, which have been quarried at several places in Walker county for commercial purposes.

The total thickness of these sandstones will not fall far short of one hundred feet.

At the base of the Miocene deposits and in contact with the uppermost fossiliferous brown sands of the Eocene, there exists a series of thinly stratified blue shaly clays interstratified with brownish blue sands and popularly known throughout the region as soapstone.

Throughout the sandy strata of these beds numerous crystals of selenite of all sizes are found, but so far no fossils have been observed.

*Some of shells found in this deposit are now in the hands of Mr. W. H. Dall for identification.

† See R. H. Loughridge's Report on the Cotton Production of the State of Texas, Tenth Census of the United States, Vol. V., 1883, page 679, for extension of this sandstone belt.

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These clays cover an extensive area, being found in a well near Forest, in Cherokee county, and at Crockett, Houston county, where they are exposed on the surface of the ground and in creek cuttings over a width of from three to four miles of country, and are also found in Wells near Paso and Lovelady. They are also exposed at Alabama Bluff on the Trinity river where they cross into Leon county. In the bluff these clays rest upon the same fossiliferous brown sands as in Collin's branch and other exposures around Crockett. The same clays are exposed on the Houston, East and West Texas railway, near the Angelina river in Angelina county, and extend southward to the foot of the gray sand ridge in Polk county two miles south of the Neches river. The same clays are again seen about a mile east of Corrigan, where they pass under the soft white diatomaceous earths belonging to the sandstone belt. The exact area of these deposits is not known, but so far as the present investigation goes, they appear to occupy a belt of country about twenty-five miles wide and to have a thickness of thirty feet.

The extensive lignite deposits of western and southeastern Houston and northern Trinity counties are found in the region occupied by these clays.

Owing to the total break in the character of the material between these clays and the underlying fossiliferous greensands and iron deposits, these beds have been tentatively assigned to the Miocene division. They may, however, upon further examination be placed in an intermediate group, and may probably be found to be representative of the Oligocene beds.

EOCENE.

Immediately underlying the Miocene deposits, and closely connected with them by the series of laminated sands and clays and gypseous massive clays and sands already mentioned, comes the older Tertiary deposits of the Eocene. These deposits have here been given a thickness of about 1500 feet, and have been divided into an upper and lower division, corresponding very nearly to Dr. Penrose's Timber Belt beds and Basal clays.*

All or nearly all of Penrose's Timber Belt beds have been assigned to the upper division of the Eocene.

The general facies of these beds are iron ores, mostly clay ironstone or carbonate of iron and some laminated iron ore, thinly stratified fossiliferous and unfossiliferous ferruginous sandstones and sands, fossiliferous and unfossiliferous altered and unaltered greensands, green and black fossiliferous clays, green and blue fossiliferous marls, thinly laminated clays and sands, with occasional deposits of lignite, the fossiliferous greensand beds predominating everywhere throughout the area.

* See First Annual Report, pp. 19 and 22.

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Areally these deposits occupy a broad stretch of country, the line of the section passing over them from near Edgewood station, in Van Zandt county, where they overlie the lower deposits, to the northern edge of the Miocene deposits in Cherokee county, a direct distance of about 110 miles. The exact lines of contact between the overlying Miocene as well as the lower Eocene, or Basal clays, have not been accurately determined, nor, from the sections as yet seen, does it appear possible to do so. At the base of the Miocene deposits and on the top of the Eocene there lies a series of thinly laminated blue clays and sands containing numerous crystals of selenite and gypsum. These have for the present been assigned to the Miocene, but some of them may ultimately be found to belong to the underlying Eocene. On the other side, or at the base of the Eocene marl beds, the upper beds of the lower Eocene grades up into the sands lying at the base of the upper division. The change is so gradual that in the absence of fossils it is almost impossible to determine the exact limits of each. The places assigned to these different beds, however, will not vary more than a few hundred yards in surface exposure in either direction.

Structurally these deposits show a peculiarity which has not as yet been noticed in any of the overlying deposits. While the general slope of the whole country is southeasterly at a small dip, many of these beds dip towards the northwest for short distances, and at other places give sections showing a horizontal disposition or present condition. These changing dips give the beds an undulatory appearance, although in nearly every instance observed erosion had completely cut off the upper folds of the beds, and in many places the apex is now worn so far down as to be occupied by a stream bed. There is nothing, however, in connection with these changes of dip to indicate that this undulation is due to any extraordinary means or anything more than the effects of the erosion of the underlying sands. This flexing or bending of these beds disappears near the southern limit of the area occupied by them, and they then present a long, gentle slope, not exceeding 16 feet per mile, towards the southeast.

While some of the deposits may be looked upon as not fossiliferous, or at least containing a very scanty fauna, the southern margin, both in Cherokee and Houston counties, is remarkably rich in fossil shells, fish teeth and small corals, and in Houston county particularly so. In the streams and washouts crossing Murchison prairie, in the northeastern portion of this county, *Cardita*, *Cerithium Whitfieldi*, *Natica* and several varieties of oyster can be obtained in great profusion. The oyster bed overlies the deposits containing the other fossils and is usually a brown sand. The underlying fossiliferous bed is a bluish green marl, stained brown upon the upper surface, and is frequently separated from the overlying brown sands by a deposit of phosphatic nodules. These nodules are very irregularly deposited, and so far as seen not more than

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six inches at their greatest thickness. This bluish green marl is known to be over twenty feet thick, and rests upon a brown laminated sand.

Southwest of the prairie, along Hurricane bayou and in Collin's branch, where the blue and brown marls and sands and carbonate of iron appear in the banks associated with each other, the fossils are numerous and mostly of a different variety. The fauna here is chiefly made up of *Volutalithes*, *Surcula*, *Pleurotoma*, *Fusus*, *Pyrula*, *Natica*, *Dentalium*, *Plicatula filamentosa*, *Conus* and others—the *Plicatula* being especially plentiful.

LOWER EOCENE.

The deposits here classed as Lower Eocene have already been described by Dr. Penrose, in the First Annual Report, page 19, under the title of the Basal Clays. Additional examinations during the last summer place these deposits as resting upon the Cretaceous marls two miles west of Muddy Cedar creek, and their upper or last deposits passing under an iron-bearing yellowish gray sand about four miles east of Wills Point, thus giving these deposits a width of sixteen miles. Their thickness is here placed at 250 feet.

In Dr. Penrose's report, already mentioned, the fossiliferous limestones are considered the lowermost beds, but this season's examination has resulted in adding a series of dark blue laminated fossiliferous clays and brown sands to the base of these beds and between the limestones and the Cretaceous marls.

The fauna of these deposits is very scanty, and consists mostly of a few small bivalve shells, most of which are very delicate and difficult to retain long enough for identification.

The limestone bowlders, hitherto considered as non-fossiliferous, show upon examination to contain a few fragments of undetermined gasteropods.

ECONOMIC GEOLOGY.

In addition to the lines of sections and other stratigraphical work during the season, investigations and examinations were made in Van Zandt, Wood and Houston counties into the economic conditions and production of the following articles, viz: Salt, lignite, iron ores, greensand marls, building stones and clays. The last named were gathered from various regions during the season's work.

SALT.

There are various salines scattered throughout East Texas, all or nearly all of which have, at different periods, been utilized for the production of salt, but the one to which most attention was paid, chiefly on account of its lying within the line of sections made and because of its being the only one now being utilized, was Grand Saline, in Van Zandt county. This is the only saline in East Texas producing salt for commercial purposes.

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The surface of the saline is a flat sandy plain, producing a very scanty vegetation in places and at others nothing in the way of plant life. So strongly impregnated is this sand with saline matter that salt has been obtained from the brine formed by the surface water leaching the sands and flowing into shallow pits or wells. This formed the principal source of the salt obtained at Grand Saline for a great number of years, and the surface of the Saline is to this day dotted over with numerous shallow wells from which these supplies were formerly drawn, while the remains of broken kettles and mounds of broken bricks show the extent to which the work was formerly carried on. Of recent years great changes have taken place. The surface wells have been abandoned and the supplies of salt are now obtained by boring wells from 300 to 500 feet deep.

The salt deposit from which the salt now manufactured at Grand Saline is obtained is a bed of rock salt lying at a depth of 197 feet beneath the surface of the saline. This bed has a known length of about one mile and is over half a mile wide. It has been found by boring to have a thickness of 300 feet of pure salt, with 18 feet of alternate layers of limestone, salt and gypsum overlying the main bed.

The salt from the main deposit when obtained in its solid form is of a pale cobalt blue color. which it loses when turned into brine.

At the time of our visit to the saline there were two salt works in operation, and a third well had been bored and works were being erected preparatory to commencing the manufacture of salt. The works in operation were the Lone Star Salt Works and the Grand Saline Salt Works. The third, the Richardson Salt Works, was expected to be in operation within the next three or four months.

The Lone Star Works obtain their supply of brine from a well 359 feet deep, of which the lower 124 feet are in the salt. The brine is formed by a stream of water found in the boring at 34 feet, flowing into the well. The brine rises to within 60 feet of the surface and is then pumped into two elevated tanks having a capacity of 50,000 gallons each. The strength of the solution when in the tanks is 30 per cent Baume, and by salometer 96 per cent. While in these tanks the brine is treated with an application of milk of lime to settle the impurities. After this treatment the brine flows by gravitation into an iron tank fitted with a steam coil, where it is heated and the remaining impurities are precipitated. From this tank it then flows into two steel evaporating pans measuring 100x40 feet and 80x40 feet respectively.

The impurities found in the brine are said to be less than 0.56 per cent, of which 0.50 per cent is sulphate of lime.

The number of men employed in connection with these works is 26, and the daily output of manufactured salt 250 barrels of 300 pounds each. The market for this salt is found throughout Texas and a portion of Louisiana.

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The Grand Saline Salt Works, situated on the southern side of the saline, are the only other works in operation. The brine used at these salt works is obtained from a well 335 feet deep, of which about 125 feet are in the salt deposit. These works employ only a few men, and turn out about 30 cwt. of salt daily. The brine here, which shows 54° by salometer or 25 lbs. of salt to 100 lbs. of brine, is pumped into a tank 18 feet long, 16 feet wide and 3 feet deep, from which it flows into a series of 14 evaporating kettles of 90 gallons capacity each. The market is mostly local.

The new Richardson Works were not in operation at the time of our visit, but preparations were being made to manufacture 400 barrels per day.

The supply of brine to be used at the Richardson Works will be obtained from a well 520 feet deep. This well has been bored clear through the salt into a gray sand, and the record of the boring shows the rock salt to have an actual thickness of 300 feet. The surface water has been piped off, and a spring issuing from the sand underlying the salt is being used for the formation of brine. The proprietors think by this means the impurities found in the surface water may be avoided.

Sections of these wells are given elsewhere and need not be repeated here.

LIGNITE.

Extensive areas of lignite occur in both Wood and Houston counties, and a deposit of the same class of fuel occurs in Trinity county near the northeastern corner.

In Wood county the lignite deposits examined occur most on the western side of the county near Alba station on the Missouri, Kansas and Texas Railway. In this region there are three distinct deposits of lignite: First, the upper bed cropping out close to the Alba Coal Mining Company's shaft, a second one near Alba, and a third a short distance north of that village. These deposits cover a known area of sixteen square miles, and while nothing is positively known about the two lower beds, the upper has a thickness of eight feet at the Alba Mine, but thickens on the dip. A section of the Coal Mining Company's shaft shows:

1. Gray surface sand . . . . . 6 feet.
2. Blue shaly (laminated) clays . . . . . 12 feet.
3. Lignite . . . . . 8 feet.

Half a mile south the section of a well shows the lignite to have thickened to thirteen feet and to have gone down forty feet from the surface.

The Alba Coal Mining Company own or control about one thousand acres of this area and are engaged in mining the lignite, drawing their supplies altogether from the upper deposit. This company commenced work in February, 1890, but did not ship any of their products

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until May of that year and since that time have shipped about thirty-four car loads of lignite,* their markets being chiefly Fort Worth and Dallas.

The mine is situated about half a mile east of the village of Alba, on the Missouri, Kansas and Texas Railway, and the lignite is reached by a shaft twenty-four feet deep. Of the eight feet of lignite about six feet are mined and one is left overhead to form a roof. Five drifts have been made into the lignite, in various directions, ranging from 150 to 265 feet each. These drifts are six feet wide and in some places roughly formed rooms from nine to twelve feet wide have been cut into their sides. The mine is ventilated by a few eight inch air shafts sunk from above, but no difficulty has ever been found on account of foul air or gas. The mine is perfectly dry, even at the face, although no provisions have ever been made for draining. The roof is solid and no timbering has been used in any portion of the mine except in the shaft and one or two props in one of the largest rooms.

The work at this mine is carried on intermittently and no lignite is mined until an order is received. The facilities for mining these deposits are good and a much greater amount can be obtained when a demand arises for this class of fuel.

Large deposits of lignite also occur in the neighborhood of Hawkins station on the Texas and Pacific Railway. This field is said to cover over a mile of territory, but its actual extent is not known.

In Houston county the lignite deposits lying in the southeastern portion of the county as well as the deposit at Hydes Bluff on the Trinity river were also examined.

From outcrops along the various streams, as well as the records of the different wells obtainable throughout the region, the southeastern coal field covers an area of about fourteen square miles and the lignite deposit is from four to six feet thick. This field is extensively developed in Trinity county where it is reported to cover a much greater area and to reach a thickness of ten feet.

At Hydes Bluff on the Trinity river, the section of the bluff shows two deposits of lignite, an upper and a lower. The upper deposit is about two feet thick and the lower nearly four feet. These deposits are exposed for nearly a quarter of a mile along the face of the bluff.

Several deposits of lignites were also seen at other places throughout the area surveyed but these were generally small and unimportant.

IRON ORES.

The main deposits of iron ores passed over, with the exception of those in Houston county, have already been described in the various reports of the Survey.†

* June, 1890.

† Reports on the Iron Ore District of East Texas, Second Annual Report, 1890.

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The ores of Houston county belong to three classes, first, Conglomerate ores; second, Laminated ores, and third, Carbonate or clay ironstone. The last of these three classes form the most important iron ores found in the county although the conglomerates are very extensively deposited throughout the central portion of the northern portion of the county. A comparatively small deposit of laminated ore occurs in the northeastern portion of the county in the neighborhood of Robbin's Ferry on the Neches river. Full details of these ore fields will be found in the report on Houston county.

GREENSAND MARLS.

Extensive deposits of these marls occur in Cherokee county and throughout the northern portion of Houston county. They occur generally in the form of a bluish green shelly marl and brown marly sand, and are exposed in most of the deep cuttings from Crockett northeasterly to beyond Alto and northerly from this line into Anderson and Smith counties. Numerous sections of these beds have been obtained and will be given later. Such analyses as have been made of the Houston county beds show these marls to be rich in lime, and to carry from 3 to 4.57 per cent of potash, over one per cent of soda and a little over 0.1 per cent of phosphoric acid.

These marls have been used by some of the farmers of the section with good results. The yellow indurated fossiliferous marls have been used in the manufacture of lime, but although suitable for agricultural purposes they were unsuitable for building operations

BUILDING STONES.

The most important classes of this material are the white, gray and bluish gray sandstones of the Miocene deposits and the yellow and brown altered greensand rocks belonging to the underlying Eocene.

The gray sandstones with their associated white and bluish gray sandstones have been traced and mapped from Rockland on the Neches westward as far as Riverside on the Trinity river. These sandstones form an almost continuous belt across this portion of the State, and are from six to ten miles wide at Rockland, and at the Trinity crossing cover an area of over twenty-five miles in width. They are quarried at various places along the sides of this belt for building and other purposes. The most extensive quarries are those at Rockland, where the stone is obtained for the government works at Sabine Pass, and at Riverside, where it is obtained for use at Galveston. The Rockland quarry shows a face of twenty feet and that at Riverside about the same. A quarry north of Corrigan, now abandoned, has a solid face of sixteen feet. Near Striker's Mill, on the Trinity and Sabine Railway, these rocks show a good quarrying face nearly one mile in length and from fourteen to twenty feet in thickness. Good building stone of the

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same class occurs near Paso, west and south of Lovelady in Houston county, and Pennington in Trinity county.

A deposit of gray sandstone occurs near Alto in Cherokee county. This deposit, however, is much broken, the stones lying in immense blocks and covering an area of fifteen or twenty acres with a few outlying deposits within a radius of a mile or a mile and a half.

The yellow altered greensand rocks occur almost wherever the greensand is to be found. These have, however, already been described in the First and Second Annual Reports of the Survey.*

INFUSORIAL EARTH.

Large quantities of infusorial or diatomaceous earths occur in association with the gray sandstones throughout the whole area, but the most extensive deposits are found in the northern portion of Walker county, where it is popularly known as "chalk." Quantities of this earth were mined and shipped north a few year ago, but for some time no work of this kind has been done. In this region the "chalk" is from six to ten feet thick and is reported to cover an area of several miles.

CLAYS.

No detailed description of the clay deposits found and examined during the course of the season's field work can be given at present. Many of them have already been described and the others are now in the laboratory of the Survey awaiting examination.

In practical use many of these clays are proved to be well suited to brickmaking and others are shown by analysis to be of proper composition for the manufacture of sewer pipes and vitrified paving bricks as well as a fair grade of fire bricks. Some others are sufficiently fine for use in the coarser class of pottery and earthenware.

Respectfully,

W. KENNEDY,
Assistant Geologist.

* First Annual Report, pp. 86–89.

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REPORT OF MR. J. A. TAFF.

INTRODUCTION.

The following is intended only as a brief resume of the principal economic results obtained during the work of the field season of 1891, the details and general geology being left for the Annual Report. The first portion of the season was spent in a reconnoisance of Southwest Texas under instructions to examine the artesian water conditions, more especially south of the Southern Pacific Railway, between Corpus Christi and the Rio Grande. The remainder of the field season was employed in a detailed study of the Cretaceous deposits of Lampasas, Burnet and Williamson counties, with especial reference to their economic values.

WORK IN SOUTHWEST TEXAS.

The work assigned me in connection with the principal object, as already stated, was to study the Tertiary-Cretaceous section, eruptives, relations of the upper and lower Cretaceous rocks along the Balcones fault, the occurrence of oil, albertite, etc.

Beginning at Corpus Christi, detailed examinations were made along the Texas Mexican Railway to Laredo, thence along the International and Great Northern Railway to the Nueces river, and from this point up the Nueces and Leona rivers to Montell, Uvalde county. This was for the special study of artesian water conditions. After this the study of the Balcones fault and the upper-lower Cretaceous contact was taken up and continued from the mouth of Nueces canyon to Austin.

ARTESIAN WATER.

From Corpus Christi westward, along the Texas Mexican Railway, as far as eight miles west of Los Angeles, there are beds of clay, sandy clay, and sandstone, following one beneath the other in layers that incline very slightly downward toward the gulf coast. The western limit of the area occupied by these rock-beds bears southward from the point eight miles west of Los Angeles and northeastward from the same point. The limit of the area is shown on the face of the country in a decided landmark, consisting of bluffs and steep declivities facing toward the west. These clays, sandy clays and limestones will not bear water in quantities sufficient to be depended upon for artesian water purposes, although, in many places, they furnish good shallow wells. The white calcareous sandstone at the base of these deposits cannot contain any considerable quantities of water, because of its impervious character. From San Diego westward this sandstone may be penetrated, but it is uncertain whether water-bearing rocks can be found at reasonable depths beneath it, for to the west of this area a later deposit of gravel and sand occupies the surface of the country

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for at least fifteen miles along the line of the section. Several wells were observed dug in this calcareous sandstone to depths of less and more than one hundred feet, the most of which afforded sufficient water for domestic purposes, stock water, etc. It is believed that some of these wells penetrated the calcareous sand, but the character of the lower portion of this bed, or the beds beneath it, are not sufficiently well known to speak positively concerning it.

On account of the late deposit of gravel and silt which occupies a great portion of the surface throughout the drainage area of the Nueces river east of the Balcones, it was difficult to keep the succession of the rocks. Large areas of the stratified rocks were concealed by this superimposed drift.

At Cotulla a well has been drilled to a depth of 825 feet by the International and Great Northern Railway company. The well gives a flow of water sufficient for the needs of the railway company and the town, but it is so impregnated by salts of magnesia and other material that it is not well fitted either for use in railway locomotives or for domestic purposes. It is probable, also, that the minerals in solution in the water would be detrimental to plant growth. The artesian well being drilled at Laredo, scarcely one hundred miles south of Cotulla, was begun in the same belt of sandstone (which does not much exceed a thickness of one hundred feet) and had been put down to a depth of twelve hundred feet, June 20th, 1891, without obtaining a flow of water. This fact gives evidence that the water-bearing rock from which the water flows in the Cotulla well is not of continuous extent towards the south.

No rocks observed can be relied upon to furnish a good supply of artesian water south of the Southern Pacific Railway, except a belt of porous sandstone bearing northeastward and southwestward through the vicinity of Carrizo Springs, Dimmit county. The northern and southern extent of this sand belt has not yet been very clearly outlined.

A continuous section could not be made of the rocks west of Cotulla along the Nueces river valley, on account of the surface covering of gravel and sand, therefore no facts were revealed from which estimates could be made for artesian water between Carrizo Springs and Laredo. It is considered possible, however, that artesian water may be gotten from the Carrizo Springs sand belt at Laredo, but the depth is not known. The extent of the artesian area east of this sand belt can be determined at present only by experiment with the well drill. There may be other beds east of this affording artesian water, but this is the only one known furnishing water of good quantity and quality. Between Carrizo Springs and Fort Inge on the Leona river, the rocks were even more obscured than they were east of Carrizo Springs. The

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drift of gravel, silt and sand continues to envelop the stratified rocks so completely that an exposure is rarely seen.

At Fort Inge, Nueces river, near the Southern Pacific Railway crossing, Frio river, at the crossing of the same railway, and at a point a few miles west of Uvalde, as well as at other points further north, near the Southern Pacific Railway, there are eruptions of basalt disturbing the Cretaceous rocks to such an extent as to prevent estimates being made for artesian water. Along the valley of the Nueces, Frio, Hondo, Sabinal and Medina rivers, above the mouths of their canyons through the Balcones plateau, for a distance not yet determined, artesian water can be gotten at reasonable depths, but between the line of hills north of the Southern Pacific Railroad, known as the Balcones escarpment and the Southern Pacific Railway, the water supply is from five hundred to seven hundred feet deeper than in the canyons.

BUILDING STONES.

Across the coast prairie, between Corpus Christi and San Diego, the rocks are friable sands and clays. Between San Diego and a point on the Texas Mexican Railway eight miles west of Los Angeles the country rock is, as has been stated, a white calcareous sandstone, rarely changing to a brownish yellow argillaceous sand, and a sand varying between the two. The white sand is generally an indurated stone, made so by the lime which fills the spaces between the grains of nearly transparent silica. It makes a beautiful building stone and is quite durable.

Overlying this white sandstone, but not of continuous extent, is a softer, almost pure tufaceous lime rock, which is employed in building stone walls by being cut into large oblong blocks by the saw or chisel. This stone is also used in house building, but is not as durable as the white calcareous sand rock. It may be of interest to state here that this tufaceous lime is geologically of quite recent deposit, for inclosed in it are the varieties of land shells now prevalent upon the surface.

From the Rio Grande, at Laredo, northward to Cotulla, there is a belt of brown sandstone in flaggy and thicker layers. The greater portion is friable and not well suited for a building stone, yet there are ledges in it that have proved to be stones of good quality as is shown by its use in Cotulla.

There are indurated beds of sandstone in the Carrizo Springs belt that are valuable for building purposes. The elegant court house at Carrizo Springs is built of it.

SOILS.

Classed according to their origin, there are three different characters of soils between Corpus Christi and the Southern Pacific Railway at Uvalde. These soils divide themselves as follows:

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First. Soils derived from the country rocks, or rocks that make up the formations of the country. For each formation the character of the soils does not have a wide range.

Second. Soils derived from material that has been transported and distributed over the country, having its origin in the rocks west of where it now rests.

Third. Soils of river and creek valleys which has its origin in the rocks of first and second.

The soils of almost the entire area between Corpus Christi and San Diego belong in class No. 1. It is very fertile, but is not cultivated extensively on account of lack of rainfall at the proper season. From San Diego westward to the Balcones escarpment a great portion of the country has been overrun by water, which has left a deposit of gravel, sand and silt, which was derived from the various rocks to the west. To this deposit belong the soils of class No. 2. They are equally as fertile as those of No. 1, and are well adapted to the growth of fruits—grapes especially, when it is possible to irrigate. To the third class of soils belong the most fertile and those having the least area. When they can be irrigated their fertility is phenomenal.

IRRIGATION.

It is useless at present to consider the matter of irrigation in this region except from flowing streams. Irrigation by artesian wells and storage reservoirs can be applied only to a limited extent, seeing that both will not now more than furnish water for domestic uses. The only source for irrigation on an extensive scale is from rivers and creeks. Zavala county is very successfully irrigated by damming the Leona river two miles above the irrigated tract. The cost to each one benefited is small, and the profits are considerable. Extensive tracts of land along this and other rivers in this region may be irrigated in the same manner.

WORK IN CENTRAL TEXAS.

The principal materials and conditions of economic value which were observed during the work in Lampasas, Burnet and Williamson counties, and which were given special attention, comprise: Building material, such as building stone, sand, brick clay, lime and cement material, road material, soils and marls, artesian water, and irrigation by storage reservoirs, springs and creeks.

Beginning at the base of the Lower Cretaceous formation, near the west line of Lampasas county, a careful section was made and studied, over an area averaging some eight or ten miles in breadth, from the point named to the upper limit of the Upper Cretaceous near the east line of Williamson county.

Previous to this, at the beginning of the regular field season, one month was spent studying the Trinity, Alternating, Paluxy and Co-

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manche Peak beds, and their relation to each other, in Erath, Bosque, Parker and Wise counties.

Plant remains were taken from the sands and from the Alternating beds that will establish their identity as belonging to the Cretaceous age. For this reason these beds are included in this section.

BUILDING MATERIAL.

BUILDING STONE.—In the Alternating beds there occur many grades of limestone. They vary from a smooth flag, which will prove useful for paving purposes, to those of sufficient thickness to be used in the construction of buildings, etc. In these beds the ledges of rock alternate in hard and softer strata, and as erosion progresses the hard limestones are left on the surface as blocks and flags ready for use in the construction of stone walls, for which they are admirably adapted. At the upper limit of the Comanche Peak bed there is a horizon, some twenty feet thick, of indurated chalky limestone, that has been used in the construction of houses, chimneys, etc. It can be sawed into blocks with ease, and is nearly perfectly white. It will not bear the stress required in the construction of very large buildings, but on account of the ease with which it may be worked, and its beauty, it will surely come into extensive use.

The Caprina bed which overlies the Comanche Peak rocks affords several varieties of good building stone. Near its base there is stone similar to that of the Comanche Peak bed, while near its center there are siliceous layers of various thickness, but they have not the beauty nor can they be so easily taken as the Comanche Peak limestone. At the upper limit of the flints belonging to the Caprina bed there is a chalk that is believed to be unsurpassed in beauty for use in ornamental construction when it is protected from the weather. It is pure white and of sufficient hardness to bear a fair polish. The Austin Marble and Washita Flags, which overlies the Caprina, contain valuable stone. The Austin Marble or Caprotina limestone, as it occurs in West Austin, bears an excellent polish and gives a pleasing effect because of the pseudomorphic fossils that occur in it in great numbers. The Washita Flags are stones of fine texture and are of considerable hardness. Some of them attain thicknesses sufficient to be used in the construction of houses.

SAND.—Sands for all uses in building, and probably suited for glass making, are to be found in the Trinity Division in any quantity. They are easy of access, and the analysis to be given in the Third Annual Report will definitely show their value.

BRICK CLAY.—The impure clays and sandy clays occurring in the Paluxy sands, near the southern limit in Lampasas county, appear to be well suited for brick manufacture. In the exposures places can be

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found where the amount of sands and clay at the surface are in almost any desired proportion for use.

LIME AND CEMENT MATERIAL.—There are several beds of limestone in the Lower Cretaceous formation that will produce good quick lime. Of these the indurated chalk near the upper limit of the Caprina bed, in which occurs the horizon of black flints, is most excellent, as is attested by the extensive White Lime Works located at Austin and other places.

Specimens have been taken from every horizon of the chalk, chalk marl, and clay of the Upper Cretaceous in Williamson county, and it is reasonably certain that when a thorough study has been made of them materials will be found which will give the proportions of lime and clay suited to the manufacture of cements.

ROAD MATERIAL.

The soil of the Upper Cretaceous limestone, chalk marl and Ponderosa marl is known as the black waxy land, because of its color and adhesive power when wet. During the rainy season the roads in this region often become almost impassable for loaded wagons. An enormous amount of labor to both man and beast is wasted because of the character of the roads, and it has been a long standing problem how to improve these roads at nominal cost.

It is the province of the Geological Survey to investigate this matter and to locate and point out the best and cheapest road making material.

The field work of the season of 1891 has developed the fact that in recent geological times almost the entire area occupied by the black waxy land in Williamson county has been submerged and overflowed by rapid and strong currents of water from the northwest, which have laid down a deposit of sand, gravel and boulders of limestone and flint, which in some places attain a thickness of strata twenty to thirty feet in depth. These flint and lime fragments are in sizes varying from that of a man's head to fine grains of sand. Over this material there has since been formed a residual soil very closely resembling that derived from the marl which underlies the drift. On hillsides, in ditches, and in ravines, the erosion which has given the region its present contour has brought the pebbly drift, flint, etc., to the surface at many places, and the flint fragments are scattered far and wide over the surface where it has withstood destruction by the atmospheric agencies which formed the soils.

Here nature has selected and assorted and deposited the best possible material for this use, and in quantities sufficient to macadamize every road in the district.

In the area west of the black waxy land there are limestones or sands close at hand to make the best of roads.

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SOILS AND MARLS.

Studies were made of the soils, their origin and their products, in the field, and selections were made of the typical ones for analysis. In a general way it may be said that the soils of the Lower Cretaceous, or hard limestone region, from Nix, Lampasas county, to Georgetown, Williamson county, except in the valleys of the creeks and rivers, are not so well adapted to agriculture as they are to grazing. The valley lands, however, are better suited for vegetable farming than are the black waxy lands, and are as well suited for the product of the cereals and cotton. The high land in this region has such a diversity of topography that over a great portion of it soil cannot form to much depth.

The value of the soils of the black waxy land is not to be estimated for the product of corn, cotton and wheat. These soils are of endless durability. Their source is a marl which extends from one foot to fifteen hundred feet in depth. Should the surface soil become impoverished by use, it is only needed to go a little deeper and mix it with the marl from which it was derived to restore it to its original fertility. In Williamson county this soil appears at the surface for a width of thirty miles, but on going northward to Red river it widens until it reaches to one hundred miles or more in width.

The soil of the drift deposit referred to above is scarcely separable from the regular black waxy soil, so close is the resemblance between them. Indeed, where the surface is level there is no perceptible difference. Even the small irregular depressions known as "hog wallows" occur in the same manner as on the black waxy land. Because of the ingredient in it derived from more arenaceous rocks than the Ponderosa marl it has, however, an advantage over the marl soil in the better production of fruits and vegetables.

ARTESIAN WATER.

In order that accurate estimates might be made for artesian water, a line of instrumental levels was begun at the western limit of the artesian area and carried entirely across it to the eastern limit of the black waxy land.

From this work estimates can be made closely approximating the depth to which wells must be bored in order to tap the water belt. The results of the work apply not only to the line traversed, but for considerable distances north and south of it as well. So soon as the limits of the rock belts extending north and south of the section line are located and mapped, any one can estimate at what depth he will have to bore for water simply by consulting the map and locating himself upon the ground. The principal of these rock sheets have already been located by the Survey from the Colorado to Red river.

It is a mistaken idea to think that artesian water can be gotten any-

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where inside the artesian well area or east of the catchment area. When locating a site for an artesian well it is necessary to know that it is lower in elevation than the catchment area or source of the water; that the water-bearing rock extends beneath it, and that there are impervious layers of rock between the surface and the source of the water. The catchment area is the area of the exposure of the water-bearing sand. This sand is occupied by the eastern border of the Upper Cross Timbers from the Colorado to Red river. Everywhere east of this line in the artesian well area the bed of water-bearing sand passes downward to the southeast beneath the hard limestone occurring between the Upper and Lower Cross Timbers north of the Brazos river and between the Upper Cross Timbers and the black waxy land in the district between the Brazos and Colorado rivers. Along the eastern border of the hard limestone area artesian water can be gotten at depths varying from 600 to 900 feet. West of the International and Great Northern depots in Georgetown and Round Rock it is not needed to bore more than about 600 feet for artesian water.

There are many points in the hard limestone area that are above the source of the artesian water, and unless the location is in the valley of one of the principal streams it is best to know the elevation compared to the elevation of the source of the water before proceeding to make an artesian well.

IRRIGATION.

Examinations were made wherever it was thought practicable that lands could be irrigated, and while it is not considered possible to irrigate any great extent of area by a single spring or well, there are many places at which gardens and small farms may be irrigated by them at comparatively little cost. A seventeen acre tract of land on the San Gabriel river, eight miles above Georgetown, is irrigated by a spring at no cost except ditching.

Irrigation may be done in a similar manner on a small scale by means of storage reservoirs, constructed by building dams across the valleys of small streams. The rivers and creeks of this region are streams of erosion, having narrow flood basins with terraces of its former deposits bordering them. In these valleys there are sufficient quantities of the most fertile lands to require all the water afforded by the streams to irrigate them. Along the south side of the San Gabriel valley for four miles above the Williamson-Milam county line, there are not less than 2000 acres that can be successfully irrigated by damming the river, provided that it will afford sufficient water for so large a tract.

Respectfully,

J. A. TAFF,

Assistant Geologist.

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REPORT OF MR. J. A. SINGLEY.

ARTESIAN WELL WORK.

AUSTIN, TEXAS, December 31st, 1891.

Prof. E. T. Dumble, State Geologist, Austin, Texas:

DEAR SIR—In accordance with your letter of instructions of March 7th, 1891, assigning me to the work of watching the progress of the deep artesian well at Galveston, I left Giddings on March 10th for Galveston.

Your letter instructed me to secure for the Survey samples of the different strata encountered during the boring of the well, and also to collect for the Museum birds, land, fresh-water and marine shells, and such other specimens of Texas Natural History as came within my power as collector.

As work did not commence on the well until early in April, I employed the interval in making as complete a collection of the birds of Galveston Island as the time allowed.

I give you herewith a preliminary section of the well to a depth of two thousand four hundred and twenty-five feet, the depth attained to this date. No determinations have as yet been made of the many species of the fossil shells, woods, etc., that have been secured, this being deferred until the completion of the well.

Commencing at the surface, to a depth of forty-six feet sand of a uniform gray color was encountered. It contained no shells or wood.

At forty-six feet the "Coastal Clays" were met. The upper part of the beds are red in color and contain fragments of shells, that of the oyster predominating.

At sixty-three feet the clay changes to a mottled red and blue color, with shells, and at eighty-four feet fragments of wood made their appearance in the stratum.

At one hundred feet a fine gray sand was met with, and continued with but slight changes in shade to a depth of two hundred and seventy-nine feet; numerous fragments of wood scattered through this stratum.

At two hundred and seventy-nine feet the sand changed in color to a reddish shade, changing again at three hundred feet to a five foot stratum of yellow sand. This stratum also contained wood fragments.

Three hundred and five to three hundred and fifteen feet, red clay, with shells.

Three hundred and fifteen to three hundred and thirty-eight feet, fine gray sand.

At three hundred and thirty-eight feet a stratum of sandstone, three inches thick and very hard, was struck.

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Three hundred and thirty-eight to three hundred and seventy-nine feet, compact gray sandy clay.

Three hundred and seventy-nine to four hundred and forty feet, fine sand of varying shades of gray, containing shells and wood.

Four hundred and forty to four hundred and fifty-eight feet, reddish clay, with shells and wood.

Four hundred and fifty-eight to eight hundred and thirty-five feet, sands varying in color from reddish and gray to white, fine and compact.

Eight hundred and thirty-five to eight hundred and eighty-two feet, water-bearing sand, coarse translucent quartz fragments. This is the sand from which most of the Galveston artesian water supply is derived.

Eight hundred and eighty-two to one thousand and eighty-nine feet, varying from a fine gray sandy clay, under the water-sand, to coarse yellow and gray sands.

At eight hundred and eighty-nine feet a hard stratum one foot thick was encountered. Samples indicate it to have been a ferruginous shell rock.

One thousand and ninety to one thousand two hundred and sixty feet, find gray sands and sandy clays.

One thousand two hundred and sixty to one thousand two hundred and eighty-eight feet, water-bearing sand, coarse translucent quartz fragments. This water-sand was struck at one thousand two hundred and forty-one feet at the Galveston Cotton and Woolen Mills well.

One thousand two hundred and eighty-eight to one thousand four hundred and ninety-three feet, sands and sandy clays, varying in color from gray to bluish and greenish.

One thousand four hundred and ninety-three to one thousand five hundred and ten feet, water sand, same as given previously, but finer.

One thousand five hundred and ten to one thousand six hundred and six feet, mottled gray and red clay, known as "joint clay," and containing a number of shells, wood fragments, and calcareous concretions, and changing to a uniform gray color at base of the stratum.

One thousand six hundred and six to one thousand eight hundred and seventy-five feet, a bed of sand, with but little variation in color or size of the grains. At one thousand eight hundred and sixty-two feet a streak of rock two inches thick was penetrated.

One thousand eight hundred and seventy-five to two thousand and twenty-eight feet, clay of gray and bluish shades, hard and soft.

Two thousand and twenty-eight to two thousand and eighty-seven feet, compact gray sandy clay, clay and sands.

Two thousand and eighty-seven to two thousand one hundred and ninety six feet, a blue clay, full of fossils, wood fragments and calca-

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reous concretions. At two thousand one hundred and ninety-six feet a stratum of about two inches of a very hard rock was encountered.

Two thousand one hundred and ninety-six to two thousand two hundred and eighty-eight feet, commencing as a very hard, compact sand, but getting softer, and filled with fragments of wood, but no shells.

Two thousand two hundred and eighty-eight to two thousand two hundred and ninety-one and five-tenths feet, a concretionary limestone, very hard, taking forty hours to penetrate the three and one-half feet.

Two thousand two hundred and ninety-one and five-tenths to two thousand three hundred and forty-nine feet, joint clay, containing many of the characteristic fossils of the Eocene formation.

Two thousand three hundred and forty-five to two thousand three hundred and ninety-seven feet, a water sand of coarse, angular quartz fragments.

Two thousand three hundred and ninety-seven to two thousand four hundred and twenty-five feet, a fine, compact sandy clay.

Operations here suspended at two thousand four hundred and twenty-five feet, the caving in of the fifty-two feet of the water-sand making it necessary. The sand will be cased off, and the well will then be bored to a depth of three thousand feet—perhaps deeper.

In addition to the data on the deep well I have secured data as to depth, flow, adaptability of the water for steam purposes, and analyses (where made) of some thirty-five artesian wells in the Tertiary formation at Galveston, Dickinson, Hitchcock, Fairwood and Corpus Christi. The records of these wells will be submitted to you with that of the Galveston deep well when completed.

Texas Birds.

While not otherwise employed during my stay at Galveston, I made, during the spring, a collection of the birds of Galveston Island comprising in all about two hundred birds. The notes on the species obtained while collecting are of much interest, especially those relating to the "bird waves" coming on the island during the prevalence of a norther, and will be elaborated for publication by the Survey. The birds have nearly all been identified, and it only remains to affix the tags and display them in the Museum.

Texas Fishes.

During the latter part of October, Prof. B. W. Everman, of the United States Fish Commission, with assistants, Drs. J. T. Scovell and R. R. Gurley, visited the State for the purpose of selecting a suitable location for the establishment of a fish hatchery, in which to propagate fish to stock the rivers and lakes of the State, and also to make a collection of Texas fishes.

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With your permission I accompanied them over a portion of the State, rendering them such assistance as was in my power. Galveston and Corpus Christi were examined with a view of establishing a combined sea and fresh water fish hatchery, oyster propagating ponds, and a biological station on the plan of the Woods Hall, Massachusetts, Station of the Fish Commission. The Neches and Trinity rivers near Palestine; the streams and bayous at Houston and Dickinson; the San Pedro and San Antonio Springs at San Antonio; the Comal and San Marcos Springs at New Braunfels and San Marcos, and the Colorado river at Austin were examined with a view to the establishment of an inland or fresh water fish hatchery. Several suitable sites were found, and Congress will no doubt be asked to make an appropriation for the establishment of the Texas Station.

A large number of Texas fishes, both fresh and salt water, were collected, also a few crustaceans. Prof. Everman is now working up the collections, and as soon as determined a collection of the Texas fishes will be donated to the Survey Museum.

Texan Mollusca.

The need of a catalogue of Texas shells, land, fresh water, and marine, prompted me to collect the data for the preparation of such a list, and I am happy to say I now have all the data necessary for the work, and part of the list is now in manuscript. I made some good collections of marine shells at Galveston and at Corpus Christi while accompanying the Fish Commissioners, and a large number, both of species and individuals, of land and fresh water species while at Palestine, San Antonio, New Braunfels and San Marcos. These collections, with the result of my ten years work on the Mollusca of the State, a few collections from members of the Survey, and the assistance rendered me by Dr. W. H. Dall, Honorary Curator of the Department of Mollusks National Museum; Mr. Chas. T. Simpson, also of the National Museum; Mr. Harry A. Pilsbry of the Philadelphia Academy of Science; Mr. W. A. Marsh of Aledo, Ill., and a number of other correspondents have enabled me to prepare a catalogue that will list all the shells that have been found in Texas to date.

The shells collected during my connection with the Survey are now in the Geological Museum and will be referred to in the list by the numbers attached to each species.

The Oyster Industry of Texas.

According to your instructions to collect data relative to the "Present Condition of the Oyster Industry of Texas," I have the honor to say that all the available statistics have been collected at Galveston,

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and gentlemen interested in this rapidly enlarging industry have promised me statistics from other points along our coast.

In conclusion, I wish to express my thanks to Col. J. W. Byrnes, of the Galveston Artesian Well Company, for assistance rendered in collecting information relative to the artesian water supply, to the many others who have rendered me more or less assistance, and to you, sir, for courtesies extended and assistance rendered.

Very respectfully,

J. A. SINGLEY.

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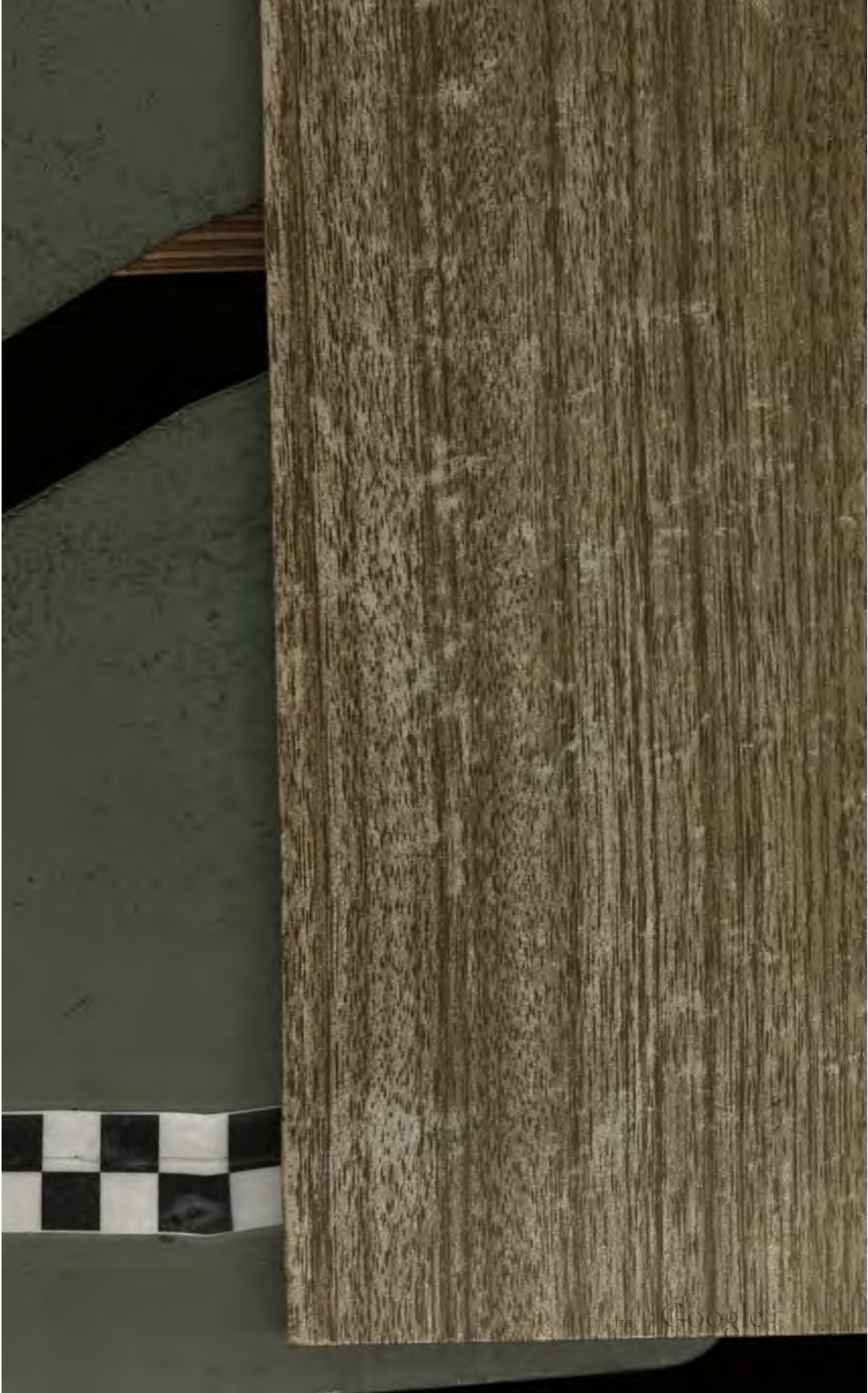
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